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Index to Advertisers and Classified Index Following Reading Matter.

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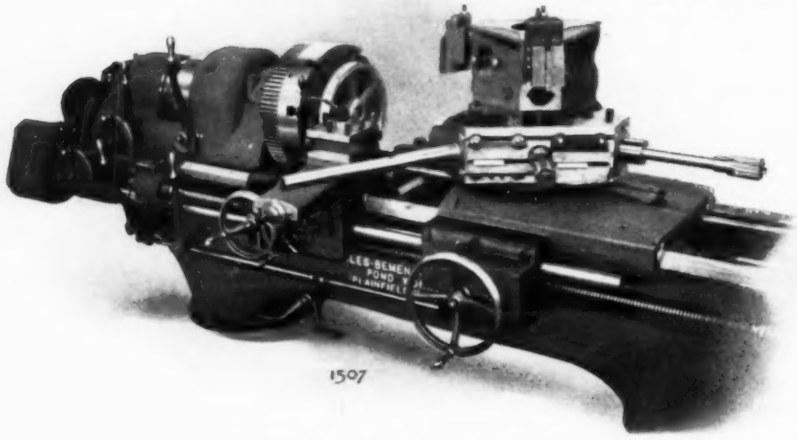

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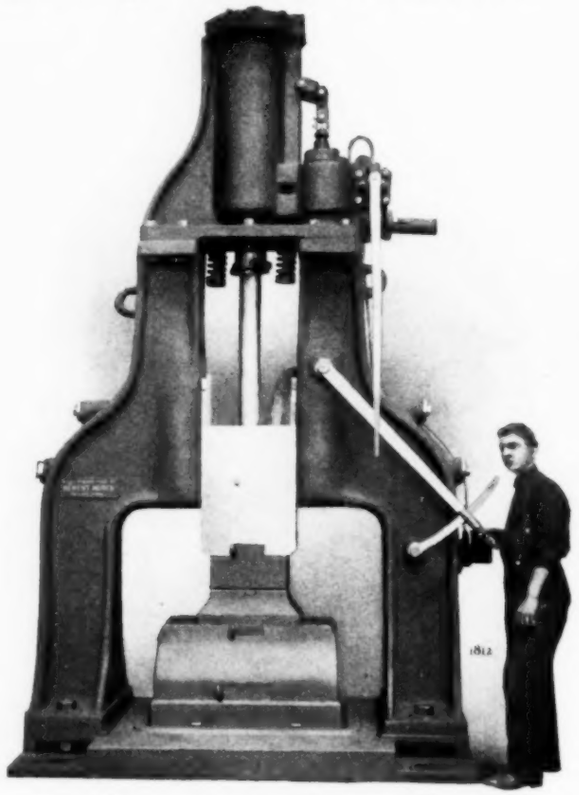

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(*See pages* 51, 52, 53, 54, 55, 56, 57 *and* 58)

Gas Power Blowing Equipment at Gary, Ind.

Essential Mechanical and Operative Features of the Indiana Steel Company's New Gas Engine Installation for Blowing Furnaces

SPECIAL CORRESPONDENCE

The almost exclusive adoption of gas engines at Gary for blowing the furnaces, as well as for electric service throughout the mills, represents the first decisive step in American steel manufacture toward full recognition of the development in gas-power equipment which has been going on for the last ten years. Outside of German practice, which has been so conspicuously successful, the only forerunners of this great undertaking in America are the gas-power plant of the Lackawanna Steel Company, at Buffalo, and the more or less experimental application by the United States Steel Corporation in the vicinities of Pittsburg and Chicago. It is not to be expected that so important a property as the Gary works would permit of the least uncertainty in the matter of gas-power application if such uncertainty existed, and it is, therefore, fair to assume that the experience of the United States Steel Corporation has been signally successful.

One of the blowing houses is now completed and together with its section of the furnaces, is now in commission. There will be three groups, virtually independent yet connected by a 5-foot gas main between the various blower houses and to be used in emergencies. The air-blast lines are not connected however, but the low-service water mains and the air compressors by which the engines are started, are connected to all.

It is to be expected that in so large an undertaking some steam reserve would be installed, which is the case, and, moreover, steam is a necessity for starting the furnaces. For each group of furnaces there is a plant of 16 water-tube boilers which supplies steam to a pair of steam blowing engines in No. 3 blowing house; a pair of 2000-kilowatt steam turbines in the electric house; a steam-turbine-driven pump in the pump house; fire pumps; hydraulic pumps and steam for miscellaneous purposes around the plant, such as steam coils for oil-settling tanks and for preventing the holder, preliminary washers and gas valves in the various distributing lines from freezing during cold weather. This boiler house is fitted for burning blast-furnace gas. This same steam reserve will be provided in each of the blowing houses to be built, as well as the electric houses, so that nothing short of a general disablement will cause the ever-dreaded stoppage of blast at the furnace tuyeres.

The blowing house contains eight gas blowing units aggregating in capacity 265,000 cubic feet of free air per minute, and in addition, two 45,000-cubic foot steam units. The layout contemplates that for each pair of furnaces three gas units will be required with a spare, the steam unit being held entirely in reserve. These 450-ton furnaces each require 44,000 cubic feet of blast per minute. As each blowing unit supplies 33,000 cubic feet of free air per minute the proportion of capacity will

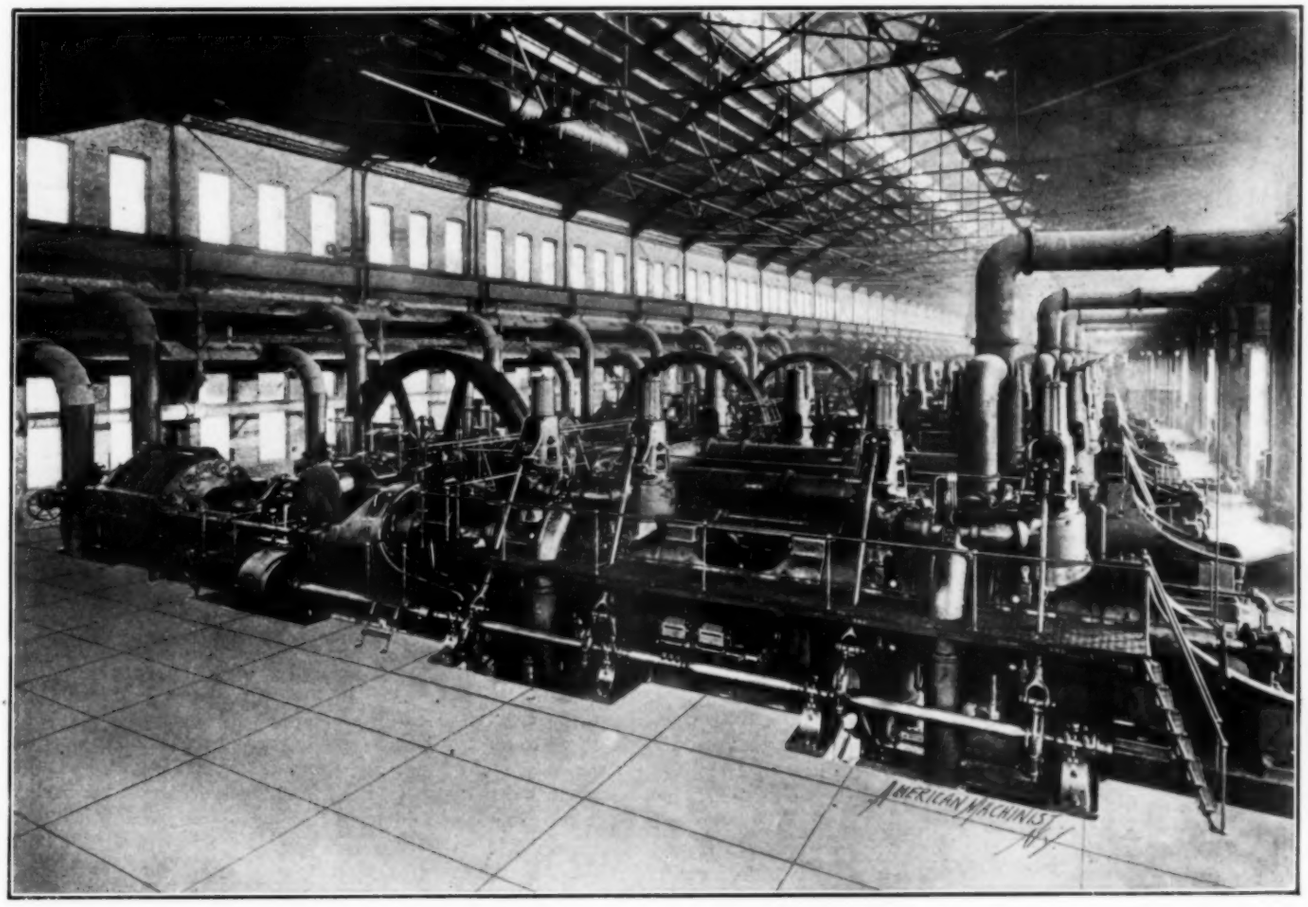


FIG. 1. GENERAL VIEW OF GAS ENGINES FROM POWER END

be evident. For the returning gas a cleaning plant capable of handling nearly 176,000 cubic feet per minute is required. The gas for the hot-blast and steam-boiler plant is only partially cleaned in the dust catchers and preliminary washers, which remove the greater part of the heavier foreign matter.

It is estimated that about 30 per cent. of the blast-furnace gas produced is required in the stoves, leaving 70 per cent. available for outside purposes, or deducting 10 per cent. for boilers and loss in washing, somewhat over 60 per cent. for gas power. Consequently the secondary cleaning plant of tower and Theisen washers needs to take care of only about 105,000 cubic feet per minute. This corresponds to the capacity of seven tower and Theisen washers, leaving one unit of each in reserve. This amount of purified gas, which now averages about 95 B.t.u. per cubic foot and will approximate 90 B.t.u. after the furnace burdens have assumed their normal condition, will develop 66,000 indicated horsepower in gas-engine cylinders well loaded, which is more than sufficient to operate the blowing house and half of the electric house. The tower washers are a modification of the Zschocke type.

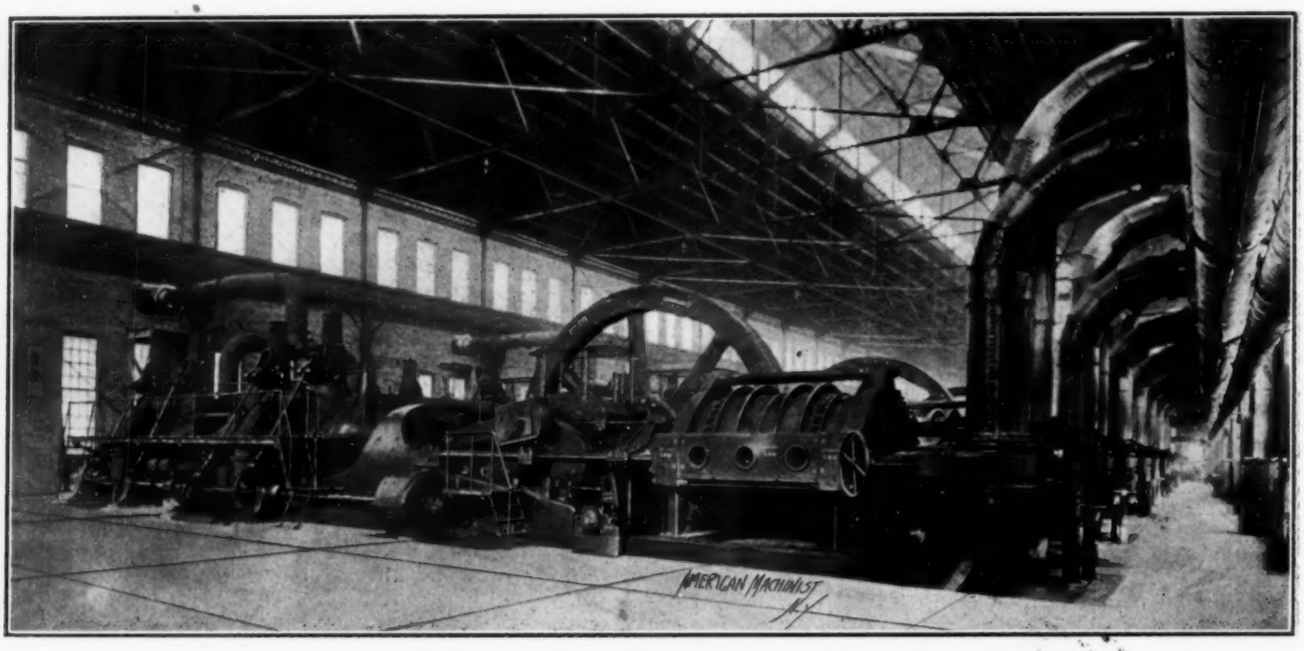


FIG. 2. GENERAL VIEW FROM BLOWING END

The Blowing Unit

The general disposition of the Westinghouse horizontal, double-acting gas engines is clearly shown in Figs. 1 and 2, Fig. 1 being taken from the power end of the near engine and Fig. 2 showing more clearly the Slick tub and driving gear. These large units are set down to the floor level with openings 17 feet wide between supporting piers to provide access to the exhaust valves. This works out quite favorably, giving a depressed floor between the two sides, 5 feet below the main floor, with galleries running along the cylinders at the floor level, as shown in Fig. 3. This avoids entirely the bad feature of an exhaust-valve pit, which was encountered in early attempts to locate the engine at the floor level. Underneath this depressed floor, which is of steel plate, run the exhaust-pipe lines.

The engine itself is in all respects identical with the builder's standard design for a 2000-kilowatt electric unit. It works on the four-stroke cycle, and is double-acting, with a compression pressure of 200 pounds at full load. No attempt at special methods of scavenging or constant compression has been made, although the valve design permits of this to a certain degree, if desired. The lay shaft is located on the outside, supported by pedestal bearings independent of the engine. This arrangement avoids the use of spiral-gear drive for the lay shaft, which is driven by spur and bevel gears, each provided with a hunting tooth to equalize the wear and practically eliminate back lash. It will be noted that both the inlet and the exhaust valves at each end are driven from a single eccentric, as usual with the large Westinghouse double-acting engines. This gear permits setting the valves so that the exhaust and inlet periods overlap, which makes possible a more perfect cylinder filling than would otherwise be possible and also a certain amount of scavenging due to the inertia of the incoming and outgoing columns of gases.

The piston rods are interchangeable, end for end, so that in case of necessity they may be transferred from one cylinder to another. The pistons are secured in place by external nuts forced up and turned off flush with the piston face. The piston itself is cast in a single piece, symmetrical in section about both axes, and without chaplets, plugs, or internal ribs. Fig. 4 shows this construction. The core is supported from inside the opening, as shown. This construction places the inner wall or hub of the piston under direct compression, relieving the bending strains at the rod considerably. These rods are not cambered or otherwise compensated for deflection, which is barely discernible, and just suffices to keep the packing rings free. All rod packings are of the quadrant metallic-ring type, not water cooled, but lubricated by the force-feed pumps.

Cooling System

Fully one-third of the cylinder jacket consists of a removable band around the center of the cylinder, so that easy access can be had to the remotest jacket spaces. The advantage of this feature has been demonstrated by previous experience of the builders with the clogging of cylinder jackets by deposits from muddy cooling water. A mud ring is provided at the bottom of each cylinder exhaust jacket which may be quickly slipped off without disturbing the exhaust-valve cage, thus opening the entire jacket space for cleaning with a hose. Cooling water is provided at a pressure of about 35 pounds for all the parts from a 16-inch main running the length of the building. A single valve controls the supply to each side of the engine and plug valves in each water circuit are provided so that the rate of flow, once set, need not be changed. These separate circuits serve all the important parts, each having a visible overflow so that the quantity and temperature of the jacket water in any circuit can be determined at any time. Each exhaust-valve circuit has a separate overflow.

Being insignificant in amount, the water is wasted, but other circuits are arranged in series as far as possible. Cylinder-jacket water enters first through the exhaust-cover chambers, escaping into the cylinder at the bottom, just under the exhaust port—the hottest part—ascending around the cylinder jacket to the top, where it overflows, always keeping the jacket full. To economize water farther, the pistons and heads are supplied in series on the countercurrent principle. After passing the front and rear heads of the forward cylinder in series, the warm water enters the piston rod at the middle crosshead, thence through the piston and out at the front end. In all cases, water enters at the bottom and overflows at the top of the chamber to be cooled so as to keep the parts full. This series system provides a fairly even temperature at all four packing glands, which would be impossible if both pistons were in series—one hot and the other cold. Telescopic supply pipes are used at the intake ends of the piston rods instead of knuckle joints.

The four individual exhaust connections for each cylinder enter a 30-inch exhaust manifold (one for each side) which communicates with an 8x10-foot brick tunnel running the full length of the building and discharging into a 100-foot stack at each end. This tunnel has an arched brick roof, but is not otherwise protected against the possibility of after explosions. All waste discharge water from the engine jackets drains into the exhaust tunnel and serves to cool the exhaust gases and thereby to reduce their volume and consequently the back pressure on the engine.

FIG. 4. 42-INCH PISTON IN ONE PIECE

Governing

Speed control is effected by means of a relay type of oil-pressure governor. The essential feature of this system is that the actual work of moving the large valves is accomplished by an oil-pressure cylinder working under a pressure of 50 to 60 pounds provided by a plunger pump driven from the engine lay shaft. The centrifugal governor is relieved of all work except operating a small pilot valve which controls the supply of oil to the working cylinder of the system. The oil pressure can always be noted at the engine gage board, and should the pump fail a small gravity accumulator serves to maintain pressure until reserve valves can be opened. In addition to the main governor, a centrifugal safety-stop device is provided at the rim of the flywheel which trips the main igniter switch at a predetermined overspeed and shuts down the engine.

Compressed-air System

As previously mentioned, the compressed air for Nos. 2 and 3 blowing houses, as well as the electric-power house, is supplied from a plant of com-

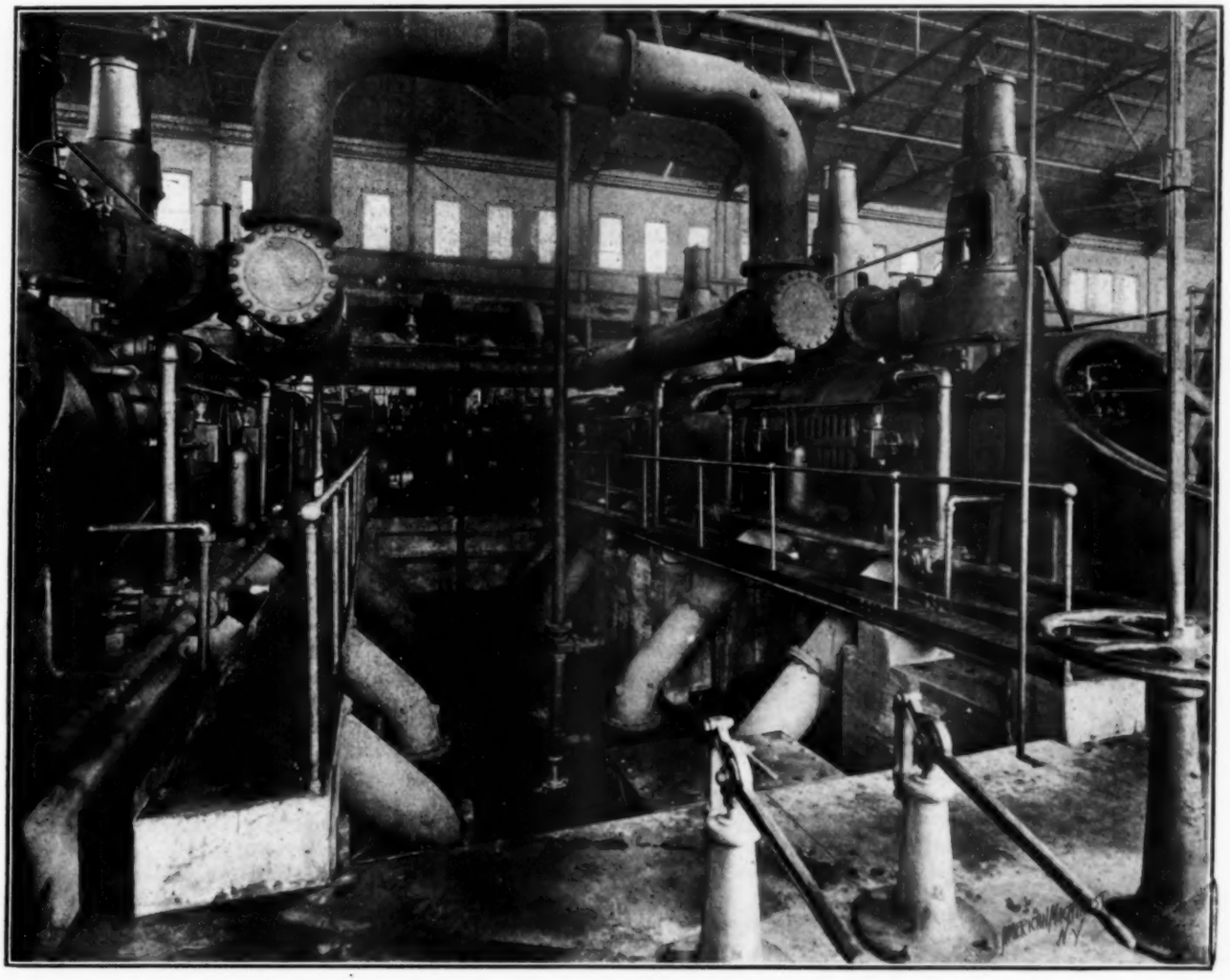


FIG. 3. VIEW BETWEEN THE ENGINE CYLINDERS

pressors in the latter building. These are 14 and 18 by 12-inch two-stage machines geared to 50-horsepower motors and each provided with automatic outlet valves which open at 200 pounds pressure. The general practice is to provide a number of steel storage tanks for compressed air, holding the majority of these in reserve in case of a breakdown of the compressing plant, but owing to the great length of the buildings at Gary, the somewhat unusual system of a single-pipe main of extra-large size has been employed. This main is 30 inches in diameter and extends the entire length of the building at the rear, beneath the operating floor. The nozzles leading to each side of each unit are welded to the main, and Van Stone high-pressure joints connect the various sections. Quick-throw valves are used only at starting and reinforced by 4-inch high-pressure gate valves.

Ignition

So important a function as the ignition calls for reserve equipment. At the engine three igniters are provided in each combustion chamber, located at points in the cylinder almost equidistant, as shown in Fig. 5. All of these igniters are supplied through individual safety fuses, so that a short-circuit of any one will not affect the others.

Both electrodes are insulated from the cylinder body so that a double ground is necessary to complete a short-circuit of an igniter. Grounding, however, usually occurs from sweating inside. Consequently, vents to the atmosphere are provided.

The make-and-break system is used exclusively on these engines. Although the igniter is standard with either mechanical or magnetic trip gear, the Gary engines are entirely equipped with the latter in order to avoid the excessive complications arising in the provision of three sets of igniters mechanically driven. The usual rotary timer, driven from the engine lay shaft, is used. It is thoroughly protected by an iron casing and runs in oil. By rotating the casing through a few degrees, as indicated by a graduated scale, the ignition may be advanced or retarded while the engine is in operation.

Ordinarily the igniters receive current at about 110 volts from a small motor-generator set supplying each of the engine panel boards. The motor generator is driven from the alternating-current bus-bars of the electric-power station. It is, of course, highly probable that this distant source of supply will sometimes be cut off by accident. In anticipation of such an accident connections have been provided with the storage-battery house nearby, and automatic apparatus is being constructed which will instantly throw the engine ignition circuits over to the storage batteries in case of trouble with the regular supply.

Lubrication

Both the cylinder and the engine oils are handled by automatic means, grease cups being used only on small, slow-moving parts, such as links, valve-gear pins, etc. In the design of the oiling system, provision has been made for the strictest economy in oil consumption and reliable feeding. For this purpose, the continuous-return system is used with settling tanks, filters and pumps in series. The system for No. 3 blowing house is equipped with a 2500-gallon storage tank resting upon the lower chords of the roof trusses. From this point, oil is distributed to some 30 different parts on each blowing unit at a positive static head of about 25 feet. A single valve controls the supply to each side of each unit and the various circuits are served by four groups of sight-feed manifolds. When these are once adjusted for the proper rate of flow, they need not be changed, so that the work required to maintain proper lubrication on these large engines is very small.

All the engine oil is returned to a common header leading to the basement filter plant, first reaching a group of three settling tanks 15x3¼x4 feet deep, where it is heated by steam coils and the sludge allowed to separate out (this sludge is caught and used in other machinery around the works). Next, a pair of vertical separating tanks removes the last traces of water. Finally the oil passes to a pair of special filters, from which it is pumped through a meter back to the roof tank. The fresh make-up oil is drawn from a 25,000-gallon tank which is large enough to take the entire contents of a railroad tank car (run in on the siding). As a precaution, a second 25,000-gallon tank is provided for overflow or storage.

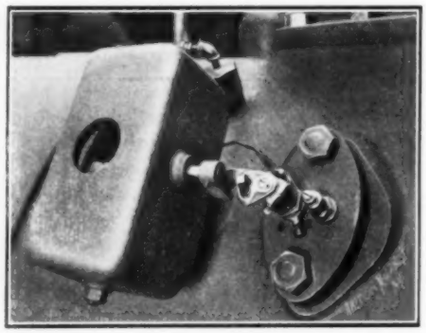


FIG. 5. IGNITER AND MAGNETIC TRIP

Cylinder lubrication is taken care of by automatic force-feed pumps driven from the engine lay shaft and embodying the special feature that the eight individual circuits leading to various parts of each engine cylinder (including rod packings and exhaust-valve stems) are accurately timed so that oil is delivered into the cylinder only just before the end of the exhaust stroke. This allows two complete strokes of the piston before combustion takes place, during which the oil is effectively spread over the surface of the cylinder. The result of this system is that oil is injected only in small quantities and at the most effective moment. The cylinder-oil circuits run about 12½ drops per minute on the large engines, at full speed; the packings take somewhat more and the exhaust-valve stems about half that rate. It is contemplated in the completed plant to serve all of these cylinder-oil lubricators (32 in number) from a central point, putting a small meter in each feeder line to determine the rate of oil consumption.

Operating Force

Much of the ultimate success of the Gary installation depends directly upon the efficiency of the operating force. Although so many of the more perfunctory operations have been taken out of the hands of the operators by the use of automatic appliances, yet a high order of intelligence is required in the few men intrusted with the care of the plants. These men must use their heads more than their hands. It may be supposed that so large a plant would require an army of men to operate it, but such is not the case. In normal operation, the No. 3 blowing house will be in charge of a chief engineer for each operating watch. Each engine crew will consist of an engineman and two oilers; the oilers will handle the blast valves during furnace operation, and the water, gas, oil and air valves when starting up, with the engine driver in direct charge at the throttle. This makes a power-house crew of about 20 men for handling 25,000 horsepower in gas engines. Considering that much of the actual work occurs in operating the valves of the blower, the amount of labor required for these engines is small, and in the case of the electric-power house even this might be reduced.

The phonograph as a commercial utility as well as a recreative instrument is already established, but now comes the announcement of a development in its commercial application that is extremely unique. A Denver inventor has brought out a device that is to be used as a phonographic lock to be applied as safe combinations. Instead of the usual safe combination of disks there will simply be a mouthpiece in the door of the safe behind which there is a phonographic cylinder mounted in the usual manner. A certain phrase is determined upon by the owner as the combination and is recorded on the cylinder; once locked the safe cannot then be opened unless this same phrase in the owner's voice is dictated into it. By a spring attachment the cylinder is set in motion. The safety of the device consists in the fact that the vibrations of the voice speaking the identical pass-words must be identical with the voice vibrations as initially recorded so that in order that the safe may be opened it is absolutely necessary that the voice of the owner do the

A 70-inch Telescoping Surface Gage

By D. H. Dugar

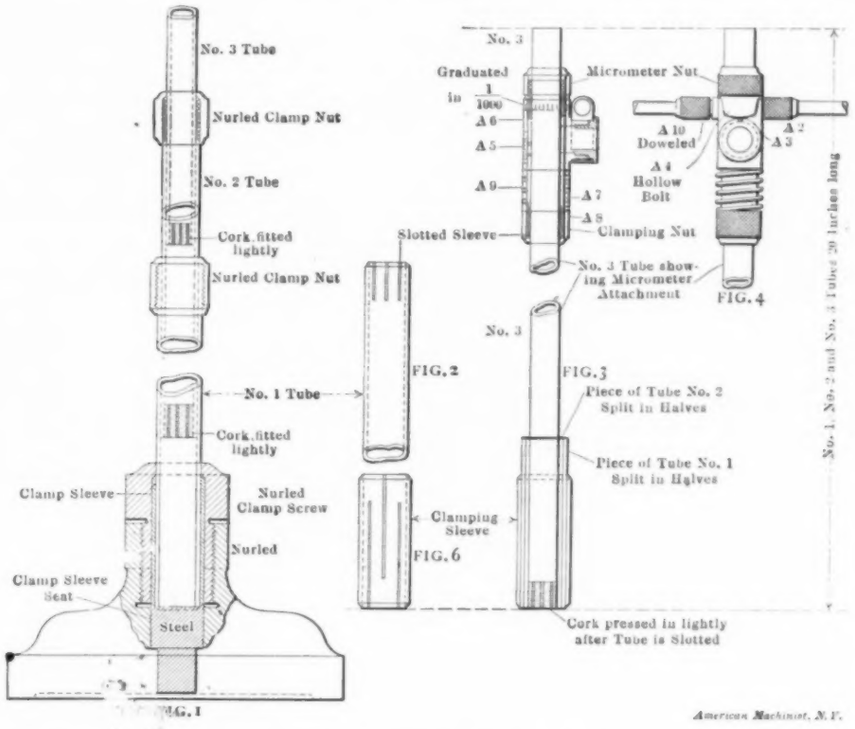
A few years ago, I happened to drop into a small shop in New England looking for a job. The big man of the place was not feeling real good and did not care very much about hiring more men, but after sizing me up with his all-knowing look, said "Well, where have you worked?" I mentioned a few fairly good shops and then waited for him to say his say, which was "There is a large number ahead of you, but you may go out into the shop and find Mr. ——— and tell him that I sent you." He then turned his other side to me and I started out to find Mr. ———.

After a few minutes' talk with this second man and a vivid realization of his tobacco-spitting habit, I received a half promise of a chance. He would let me know in a few days. Shortly thereafter, I received notice to present myself *at once* ready for work.

I remained in that shop several years, with its many ups and nearly downs, I say nearly, because when we were running low in cash, somehow or other a job would come in and the "long green" would be forthcoming. What they did was to hypothecate the new orders.

One day while looking round for a large surface gage, Mr. ———, the spitter, showed me one that they had used for several years and proudly said that it was [illegible] creations. It consisted of an [illegible]-in flange drilled to receive a ¾-inch rod about five feet long. On this rod was a square block with a hole drilled through it for the head or the part that held the pointer or scriber. A set screw in the back fastened the head to the ¾-inch rod and another one in front clamped the pointer; weight about 34 pounds. He also proudly informed me that its original cost was $1.79. I could not get him to say what it had cost since.

After my day's troubles were over, I lit my old T.D. and hatched out the telescoping surface gage that is illustrated in the accompanying halftones and line engravings. Bicycle tubing took the place of a solid rod. The method of telescoping is plainly shown. The tube No. 1 is large enough to receive No. 2, and No. 3 will just fit into No. 2. These are all mounted from a finished cast-iron base and are clamped with a nut on a slotted clamping sleeve which closes in at both top and bottom. A tempered-steel plug is provided in the cast-iron base. The form and purpose of this steel plug is plainly seen by referring to Fig. 1.



DETAILS OF 70-INCH SURFACE GAGE

The inside of tubes Nos. 1 and 2 are reamed and carefully lapped to insure a smooth sliding fit after the clamp nuts are loosened. The bottoms of tubes Nos. 1 and 2 are slotted and are fitted with a cork stopper. This gives a small amount of spring, makes a snug fit and helps to give the entire rod stability.

The body of the micrometer head is made from a malleable-iron tee (see part *A 6*. This was bored out to the right size to pass over tube No. 3. A piece of No. 2 tube stock was fitted at the top for the micrometer nut; I used 40 threads per inch. At the bottom it is threaded with 24 threads per inch and slotted for a clamp nut. A small helical spring with open coils was placed under the tee as shown by *A 7*. This was to keep the tee against the micrometer nut and not against the clamp nut *A 8*. In order to keep *A 7* from turning around on the piece *A 9* a slot was cut in the back at *A 5*, and a piece of No. 1 tubing used as a key riveted to piece *A 9*. At the side of this key are graduations reading hundredths and thirty-seconds with micrometer graduations reading to thousandths. These are all the graduations that are needed on a tool of this kind.

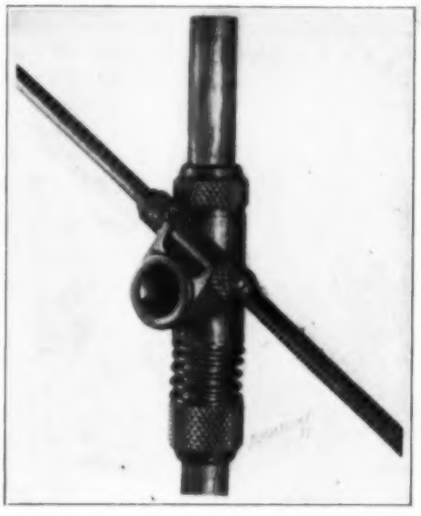


FIG. 5. MICROMETER HEAD OF 70-INCH SURFACE GAGE

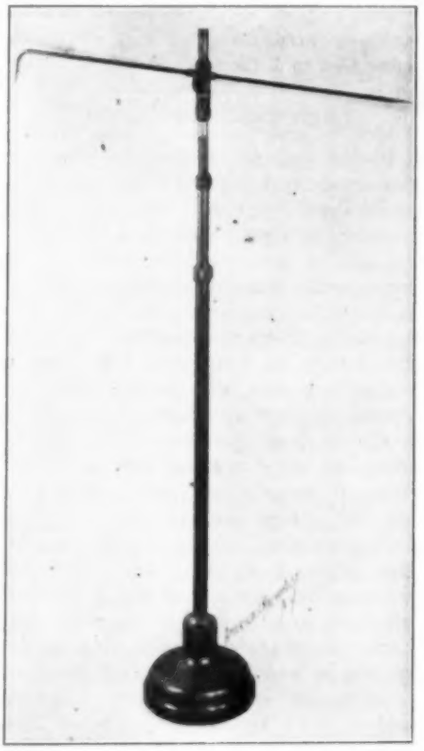


FIG. 7. 70-INCH SURFACE GAGE ASSEMBLED

At the bottom of Fig. 3 is shown a short piece of No. 1 and No. 2 tubing. These are used with No. 3 tube in order to adapt this tube to the base and thus use the pointer on low work. A little study of Fig. 3 in connection with the clamping sleeve of the clamping screw at the base, will show how this arrangement is effected. Fig. 4 is another view of the micrometer carrying the pointer or scriber. At *A 3* is indicated a flat piece of steel bored out thin and slotted at the upper part of its bore. In the two prongs running up at the side are holes drilled for and fitted with a hollow sleeve *A 4*. At one end of this bolt is a nurled nut having 24 threads to the inch used to clamp *A 3* to the side opening of the tee. The piece *A 3* can be swiveled around for the purpose of changing the pointer as desired.

Referring again to Fig. 4 one end of *A 4* is used to clamp *A 3* and the other end has a nurled nut for the purpose of fastening the pointer. This sleeve has a dowel pin at *A 10* so that it will not revolve in *A 3*. As the side opening of the tee *A b* was not long enough for the swivel a ⅜-inch extension washer was used as shown, thus getting the swivel close to the micrometer and avoiding any overhang.

Fig. 5 shows the head, pointer and micrometer graduations. Fig. 7 shows the assembled tool, though not fully extended.

High-speed Tool Steel *

In our issue of March 2 we dealt with the question of improved high-speed tool steels from a general aspect, and we now propose, as then promised, to give some account of the actual tests—carried out at several Sheffield works recently—on which the opinions expressed were founded. It must, of course, be understood that the tests were brief, but, as far as they went, they were regular shop tests under normal conditions, except that in certain cases—particularly with Saville's tools—the speed and feed were put at such a point that the tools were rapidly destroyed. These destruction tests are not, in our opinion, wholly satisfactory, but they afford a means of obtaining rapidly comparative results, and unless one was prepared to give days to it, many tools could not otherwise be tried. It is as well to bear in mind, however, that the virtue of high-speed steels is, first, that they will endure much longer at high speeds than other steels, and, second, that they will cut metal at reasonable speed that other steels will not touch at all. In ordinary shop work the prudent manager will always use them comfortably within their maximum output. This is particularly so in boring. It is practically impossible to bore a long hole perfectly parallel; the tool wears and the hole gets smaller toward the far end. If the tool fails and a new one has to be put in in the middle of the bore, a mark or change of diameter is almost sure to occur. For such work these high-endurance tools are invaluable. With a light cut and moderate speed the wear is inappreciable, and a very long bore may be made more accurately than with less enduring tools. We now give the tests.

At Seebohm & Dieckstahl's works we were shown some very effective tests on a large bar of high-speed steel. Experiments are carried out very methodically by this firm, and an excellent test house has been built for this sole purpose. The principal machine in it is a large Dean, Smith & Grace lathe driven by 40 horse-power motor and served by a convenient runway that enables heavy test bars to be handled easily and quickly. A number of short, stiff shafts of cast iron and steel, of which the analysis is well known, lie on the floor and can be lifted into the lathe as desired. They are all so large in diameter that there is no fear of their bending under the stiffest cuts. In some cases, as on the occasion of our visit, a large high-speed steel casting weighing many hundredweights, and destined ultimately to be cut up into high-speed milling cutters, was used in this lathe. In such large castings hard spots near the surface are unavoidable, and the steel is turned down until none are left in the part required, which is then sawn off and made into cutters. The hard places show as bright spots during turning, and, needless to say, they are extremely trying to the tool. In the tests we witnessed several were encountered and safely overcome without damage to the cutting edge. The test itself was simple. The test bar, which, it must be remembered, was of high-speed steel itself, carefully annealed, of course, was 5 15/16 inches diameter, and was reduced to 5 9/16 inches, that is a ⅜-inch reduction; the feed was 1/16 inch, and the speed 33 feet 9 inches per minute. Two tools were tried. The first ran for 15 minutes without regrinding, traversing 22½ inches of the shaft. The second tool had 23 inches of shaft left to run at the same reduction; this it did in 15 minutes; it was then drawn back and a new cut started with a ⅛-inch feed, the speed and cut remaining as before. It ran for no less than seven minutes, and covered 18 inches of shaft, and at the end of the test was still in very fair condition. The work was run dry, and the heat generated was so much that even a shaft so large as that under test became rapidly almost too hot to touch.

A number of independent tests have been made by users of Seebohm & Dieckstahl's steels, and we are permitted to give the results of a few of them, while withholding the names of the firms who made them, of which, however, we are ourselves in possession. The steel is called Ultra Capital Water-hardening. Here is a test with a tool 1¼ inches square operating on a wrought-iron tailshaft: The Ultra Capital tool was put in the front rest of the lathe and was working on the scale throughout. A standard high-speed tool of precisely the same section and shape was put in the back rest and was working on clean iron. The speed varied slightly between 44 and 50 feet per minute, the feed being ⅛ inch, and each tool was reducing the diameter of the pin by ¼ inch, which equals a ⅛ inch depth of cut. The standard high-speed steel tool traveled 11 inches, and failed. The Ultra Capital steel ran for 14 feet 6 inches before giving out. One feature of this test was that both tools were prepared and hardened by the customer's own smith.

Tool.	How Hardened.	Duration of Cut.	Weight of Cuttings.	Remarks.
"A"	Water	2 min.	3½ lb.	
Triumph	Water	20 sec.		
Triumph	Water	3½ min.	6¾ lb.	
"A"	Air	12 sec.	3 oz. 13 gr.	
Triumph	Air	19 sec.	8½ oz.	
Triumph Superb	Water	30 sec.	13¾ oz.	
Triumph Superb	Air	17 sec.	7½ oz.	
Triumph	Air	26 sec.	11 oz.	Cooled on floor of smithy.
Triumph	Air	49 sec.	1 lb. 6½ oz.	17th grind.
Triumph	Water	20 sec.	7¾ oz.	Square-nose tool.
Triumph	Water	31 sec.	1 lb. ¾ oz.	Same tool re-ground.
"A"	Water	13½ sec.	6 oz.	Hardened by Saville & Co.
"A"	Water	32 sec.	14½ oz.	Same tool re-ground.

Test bar, hard cast iron. Speed, 60 feet per minute. Reduction of diameter, ¾ inch. Feed, ⅛ inch. Worked dry.

TESTS OF TOOL STEELS AT NASH'S TEST HOUSE, SHEFFIELD.

Here are several other tests with a tool of the same size:

A sliding pinion of very hard steel, 10½ inches diameter: The standard high-speed steels turned it with considerable difficulty, but the new steel finished it at 52 feet per minute, and at the end of eight minutes was only slightly worn.

A hard-steel lathe spindle on which the ordinary high-speed steels stood only 20 seconds. The new tool ran for 6¼ minutes at between 72½ feet and 80 feet per minute, with a 5/16-inch reduction and 1/16-inch feed.

A 68-ton Vickers steel shaft for test purposes: Highest cutting speed, with ordinary high-speed steels 40 feet, with new steel 60 feet, was attained, and at the end of four minutes the condition of the tool was good. The reduction was ⅜ inch and the feed 1/16 inch.

*From *The Engineer*.

A fine test was made on a cast-iron face plate 36 inches diameter. A roughing cut was to be made, breaking the skin, and the tool was subject to the hammering due to the slots. The depth of the cut was irregular owing to the uneven face of the casting, but may be taken as approximately ⅛ inch. The feed was 1/16 inch, and the speed was kept constant by a Lang's variable drive at 99 feet per minute. The tool went right across the plate, and was in perfect condition at the end of the test, having left a good finish.

At Edgar Allen & Co.'s works an impromptu test was arranged for us. This firm is also making an extra special steel, which can be hardened in water at 1200 degrees Centigrade, with less liability to crack than the old high-speed steels, but excellent results can be obtained by air or oil hardening at 1300 degrees Centigrade in air or oil. We may say here, while on this question of cracking, that it not infrequently happens that the highest results are obtained with a cracked tool. In our own tests we had one or two striking instances of that fact. More often than not if cracking occurs at all it takes place in a line more or less parallel to the lathe bed and longitudinal of the tool, and as the joint does not open, but is only visible as a very fine line, the lower part of the tool supports the upper. It is held by some smiths that the superior cutting powers of a cracked tool are due to the fact that it has been hardened at a higher temperature; but this is not thoroughly borne out by other facts, and it seems more probable that there is some nature in the steel that makes it, as might be expected, both hard and brittle at the same time. An interesting fact about all high-speed steels is that very frequently they will be better on the third, fourth, or fifth grinding than on the first, and we have seen a tool that did badly greatly improved by hard grinding. This seems to suggest that somewhere, just under the skin, the metal was at the critical temperature at the moment of plunging. It must be remembered that there is no color guide to the temperature with these high-speed steels, and regular results are less easy to obtain than with ordinary carbon steels. There would seem to be an opening for a really good hardening furnace in which certain predetermined temperatures could be obtained with certainty. However, this is a diversion, and we return to our visit to the Tinsley works.

The test made for us by Edgar Allen & Co. was carried out on a 20-horsepower electrical lathe in the shops. The shaft was a 0.60 carbon steel; the reduction 5/16 inch and the feed 1/25 inch. The speed was very high, namely, 110 feet. Under these conditions the tool ran exactly 3 feet 2½ inches without any signs of wear, and it was then brought back and started with ¼-inch reduction at the same speed and feed, and ran for 11 inches before being removed. It was not even then seriously worn, and might have continued at work, roughing, for some distance farther. The test was made particularly to show the endurance of the tool at high temperatures, and for this reason a great speed was used. During part of the time the edges of the turnings were coming off red hot, and the tip of the tool could be seen glowing when partly shaded. A match lightly touched upon the tool ½ inch back from the point ignited immediately.

Edgar Allen & Co. are strongly in favor of wet grinding on a grit stone. Emery, even with a copious supply of water, has a tendency to cause great local heating, and not infrequently appears to draw the temper of the steel. This seems odd in view of the fact that these high-speed steels will work when the edge is at a bright cherry red; but the fact is confirmed by other Sheffield tool-steel makers, and the general opinion is that if emery is used attention must be paid to the amount of pressure that is applied which should never be allowed to exceed a moderate degree. It should not be difficult to design a grinding machine in which the amount of pressure applicable would be readily adjustable to a predetermined maximum. It would be instructive to know if under such circumstances emery grinding was less satisfactory than stone grinding.

At Samuel Osborn & Co.'s works a shop test was also shown us. It was prepared a little hurriedly, and the work vibrated a good deal under the cuts imposed, which was not entirely satisfactory, but possibly made the work done the more notable. Osborn's name has always been connected with Mushet steels, and the same name has been retained for their latest production—extra double Mushet—which, by the way, has been on the market since September last. This steel, so the makers inform us, has turned up nine locomotive steel tires without regrinding, as against the 1¾ turned by former steels. We did not see any tests on such hard material as that, the bar used for our experiments being a "seventy" carbon steel with 1 per cent. of manganese. Quite a small tool, only ⅝ in. square, was used. The bar was reduced ⅜ inch with 1/16-inch feed, and the speed was 70 feet per minute. The tool stood well at this speed, and in order to test it to destruction we increased the speed to 120 feet, at which it continued to cut for a short time, the reduction being 5/16 inch.

An elaborate series of tests had been prepared for us by Mr. Carter, of Saville & Co.'s works. The managing director of these works is, as many of our readers are aware, Mr. Coppel, a steelmaker who appears to carry on the traditions of the Sheffield of the past and have an instinctive knowledge of what any particular ingredient will do to a steel before it has ever been tried. Rumor relates that one of his latest most successful "physics" was hastily prescribed after dinner, and that a wonderful tool was produced with little or no experimenting in three days.

A dozen tools were used for the tests, most of them made by Saville & Co., and known as their Triumph and Triumph Superb brands, but some by other makers. All these tools were hardened before us in different ways, some in a blast of air, some in oil, some in water, and one by simply lying on the floor of the smithy to cool. To heat them a good clean fire was made of ordinary smith's coke, but just in the heart of it a few lumps of the best furnace coke were placed so as to bring the temperature up to the great hight required — something over 2500 degrees Fahrenheit. For air and oil hardening only ordinary precautions in heating up are required, but for water hardening the temperature must be raised slowly. When the tip of the tool is approaching the necessary temperature the coke is pushed back from it and the blast increased. The tip being kept in the hottest zone, is watched through smoked glasses until the steel begins to blister and bubble and is actually on the point of melting; the tool is then drawn from the fire and plunged almost instantly into the cooling medium; if into water or oil, the tip alone is dipped in and moved about freely until the general temperature has become a good deal reduced, when the whole tool is plunged in and moved about.

One tool of Saville's own make received at our request the severest possible treatment with water hardening, and we succeeded in cracking it, but all the others which were treated with a reasonable amount of care showed no signs of cracking. With air and oil hardening, indeed, there is little or no danger of cracks, and we were informed that the extra special steels are less liable to split than the ordinary high-speed steels of a few years ago.

A dozen tools were got ready, and were taken to Nash's public testing house. A good Darling & Seller's lathe is here used, and it is fitted with an electrical speed controller with a tachometer in front of the operator, so that there can be no doubt about the actual speed of cut. We checked it also from time to time with a cut meter. The tests were carried out by the staff of the test house and were quite independent, but the figures we give are our own observations. The test bar was of hard cast iron. The speed was kept as near 60 feet as might be, and the cut was ⅜ reduction with a 1/16 feed. All the tests were carried to destruction, and the condition of the tool is, therefore, not specified. The tools marked *A* are recognized brands of extra special steel. In the first two cases it was hardened by an independent experimenter of repute. As the tests were not competitive, we do not give the names of the other makers.

It will be seen that there are curious anomalies in the results of all the tools

used. Note particularly Nos. 1 and 3, which, in view of the remaining tests, must be regarded as marking a very high stage of development indeed. The "Triumph" steel, by the way, we were told by the makers, has been made for nearly two years; Triumph Superb is the new steel.

Tests on a forged steel bar followed the tests on cast iron, but, unfortunately, we were unable to witness them, as a slight accident occurred which delayed the experiments; we trust, however, to be able to give them later from the official records. They are, of course, very much longer runs than on cast iron. A tool, for example, has cut steadily for 26 minutes at 50 feet per minute with a 1/16 feed and 3/8 reduction. The longest cast-iron test with a Triumph Superb tool of which we have seen an official record is 7 minutes 21 seconds at 60 feet with a 3/8 reduction and 1/16 feed.

A German Electro-Magnetic Brake for Shafting

By I. W. Chubb

One advantage of electrical methods is to be found in the safety devices that they render possible. Thus in connection with the electric driving of workshop shafting, etc., the firm of Felten & Guilleaume-Lahmeyerwerke, Frankfort-on-Main, is making an electro-magnetic brake, that can be coutrolled from any part of the shop. One or more brakes are used on a length of shafting, according to the braking power required. As the firm has noted in its own experience, it is always possible to short-circuit the motor and thus use it as a direct brake; but with a belt drive there is always the accompanying danger that the belt may come off.

In the type which this firm is now making, and has, in fact, installed in the repair shops of the Prussian State railway at Lauban, the brake acts directly on a drum, or pulley, keyed to the shafting. A counterpoise brake (see Fig. 1) has two brake blocks which are brought into action by the fall of a weight; the lever which carries this weight is tripped electromagnetically. The diagram of connections, Fig. 2, will show how this is arranged, and applies both to direct and single-phase alternating-current circuits. A remote-control switch *A* is connected to the supply mains, as shown, and the coil of this switch can be put into circuit by any of the push buttons *B* which are placed in convenient positions. The coil controls two double-pole switches, one for the motor *C* and the other for the brake-magnet *D*, or magnets, if more than one brake should be fitted to the shafting. These double-pole switches are interlocked so that if one is in circuit the other is out. Thus either the motor or the brake magnets will be connected to the mains. Each brake magnet is also protected by a double-pole switch *E*.

The magnet coils carry current intermittently, the magnets being used simply, as stated, to trip the weight lever. On pressing any of the buttons the remote-control coil automatically cuts the motor out of circuit and at the same time completes the circuit for the brake. The balance weight at each brake is, therefore, released by the opening of the catch and the brake

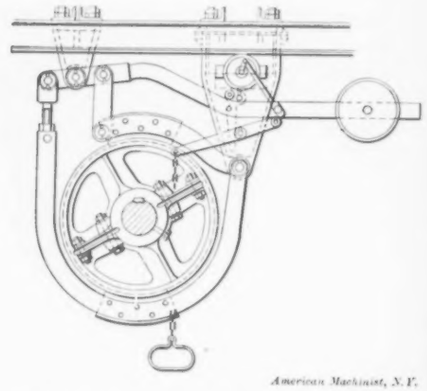


FIG. 1. ELECTRICALLY-OPERATED LINE-SHAFT BRAKE

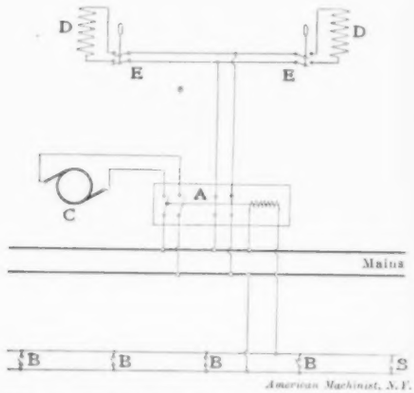


FIG. 2. WIRING DIAGRAM FOR ELECTRICALLY OPERATED LINE-SHAFT BRAKE

FIG. 3. ELECTRIC MOTOR AND LINE-SHAFT BRAKE AS INSTALLED IN PRUSSIA

blocks are brought into operation mechanically. Almost simultaneously the double-pole switch for the magnet is thrown out of circuit by the movement of the lever; the mechanical connection is made plain in Fig. 1. Thus the current is cut off the magnetic coil.

To restart the shafting, the remote-control switch changes once more the position of its double-pole switches, so that the motor is again in circuit. The brake is then freed by means of the chain and handle, a rocking lever lifting the weight and causing the catch to engage once more. At the same time the movement of the weight lever brings the double-pole switch of the magnet into circuit again. This cannot be done unless the remote-control switch is in the correct position; otherwise the brake magnet would again come into position and trip the weight, keeping the catch inoperative. The switch can, however, be put into circuit after the motor starter has been brought to the off position, and the firm recommends the use of starters fitted with no-voltage releases.

Fig. 3 shows the brake in use in the shops of the Prussian State railway, Lauban, as mentioned. Here a Renold chain is used for driving in place of a belt, owing to the short centers. The connections for direct and single-phase alternating currents are obviously quite simple. For three-phase current, besides the motor, three brake-lifting magnets are in the circuit, one in each phase, while the coils of the remote-control switch and the push buttons are connected to one phase.

German Rotary Files

The development and use of rotary files has been carried to a considerable degree of refinement by the Deutschen Waffen- und Munitionsfabriken, of Berlin, Germany. These files are made in a wide variety of shapes and sizes, as illustrated in Fig. 1. But little comment is necessary, except to point out the various methods by which these files are fastened to the spindle of the machine in which they are used. No. 28 shows a taper shank. Nos. 22, 30 and 35 show straight shanks. Others, as Nos. 21, 32 and 36, show straight holes, which may be chambered or not. Many of the smaller ones show a tapped hole, whereby they are screwed to the nose of the spindle.

In addition to the large number of sizes and shapes, there is as large a variety of cuts as is found in ordinary hand files. By this provision the files may be adapted for various classes of work, from that which requires a finish such as produced by fine files, to another which can be done by a coarse file. Furthermore, they are used for all kinds of metals, iron, steel, bronze, and the like. To get the best results, the speed of a given file should be adapted to the work which it is to do. For illustration: Files which have a diameter of from 10 to 25 millimeters (0.4 to 1 inch), should have a speed of 2000 revolutions per minute for iron and steel, and similar hard metals. On the other hand, a file of the same diameter should have a speed of from 2500 to 3000 revolutions per minute for brass and other soft metals. The German firm to which we have referred uses these files for many operations on small parts, such as the removing of burs, cleaning out of holes and cavities, machining small surfaces to exact dimensions, and the like. For many such uses exact file shapes are required, and these are made within the limits of 0.1 to 0.2 millimeters (0.004 to 0.008 inch). The statement is made that for many classes of work, saving in labor, cost and time ranges from 20 to 50 per cent. over methods formerly in use.

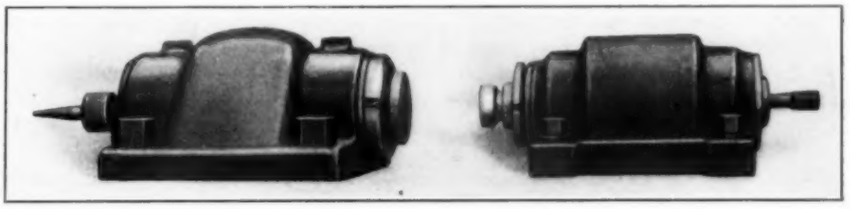


FIG. 2. MACHINES USING GERMAN ROTARY FILES

FIG. 3. GERMAN ROTARY-FILE FRAME, SHOWING BALL BEARINGS

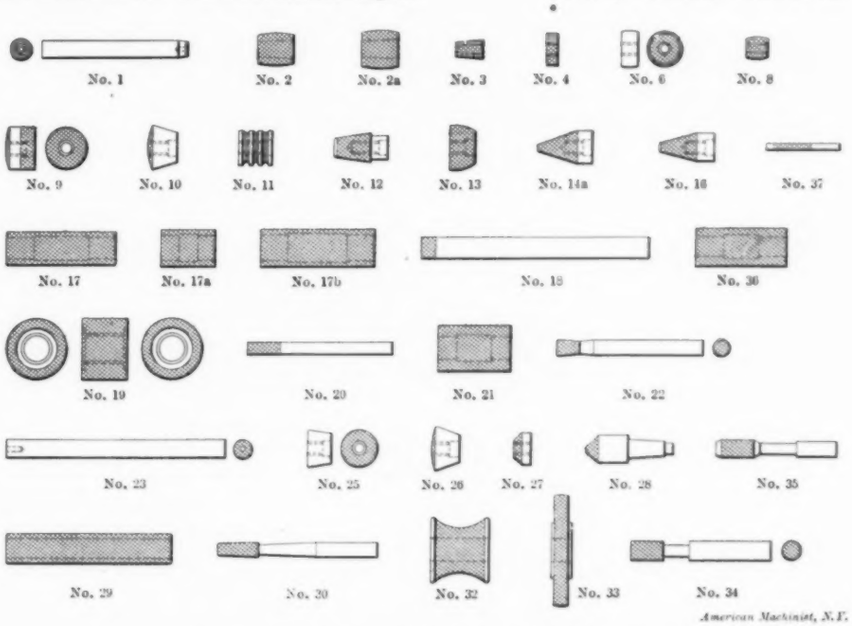


FIG. 1. VARIOUS FORMS OF GERMAN ROTARY FILES

These rotary files are used on various types of machines resembling small grinder or buffing frames. Fig. 2 shows two of these machines arranged for a vertical belt from beneath. The interesting feature of the design is the use of ball bearings for the spindle. Fig. 3 shows one of these machines partially disassembled in order to show the ball bearings, and at the side is a ball bearing of the type which is used. Their use aids in obtaining the high speeds which are necessary, saves power, and tends to eliminate lubrication troubles. The American agent for these rotary files and machines is the Hess-Bright Manufacturing Company, of Philadelphia, Penn.

Comparative Tests of Two Shapers

One Had V Gibs, the Other Square Gibs. The Tests Were to Determine Relative Wear, Accuracy of Work, Deflection and Power Consumed

BY HENRY P. NOBLE

During the year of 1907-8, there was carried on in the Engineering Shops of the University of Michigan, a series of tests of interest to machine-tool builders and users. This consisted in the comparison of two similar shapers, one having angular, or V-gibs on its ram; the other square, or box gibs. Both machines were built by the Gould & Eberhardt Company, Newark, N. J., and with their permission I present this account of the tests as bearing on the much discussed relative advantages of the two types.

The test was the immediate outcome of a long correspondence between Prof. W. L. Miggett, superintendent of the shops,

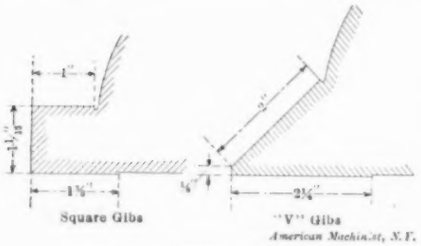


FIG. 1. DIMENSIONS OF GIBS

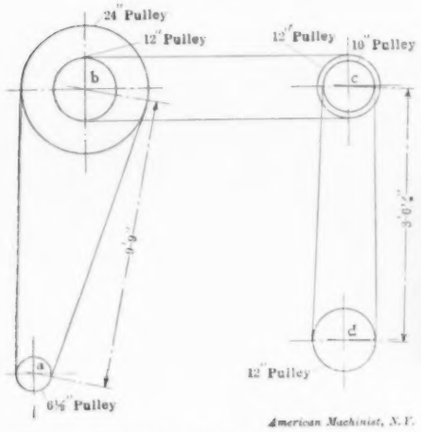


FIG. 2. ARRANGEMENTS FOR MEASURING POWER

and Messrs. Gould & Eberhardt. Professor Miggett had long wished to carry out such a test, and personally planned its methods. The manufacturers, on their part, while considering the V-form of gib superior, expressed themselves as "by no means wedded to it," and as extremely desirous of learning the exact truth of the matter.

All of the test readings were made under my immediate supervision, and no pains were spared to make the tests absolutely fair and to avoid any undue advantage to either machine.

The V-gibbed machine was one of Gould & Eberhardt's standard 16-inch extension-base shapers, taken from regular stock. The other was exactly like it with the exception of the gibs. The proportions of the gibs in the two machines are shown in Fig. 1. The bottom bearing surfaces of the slides were relieved in the middle, leaving a bearing at each end as follows: On the V-machine, 10 inches in front, 10½ inches in back; on the square machine, 10¼ inches in front, 10½ inches in back. On the V-machine, the side bearing surfaces were relieved like the bottom; on the square machine they were in contact for their whole length, or 38 inches.

Conditions Surrounding the Tests

The principal precautions taken to make the test fair and equal may be enumerated as follows:

First, power: Both machines were driven in all power tests by the same motor at a uniform speed. The motor was previously tested under various loads, input being measured by volt- and ammeter-readings of the current supplied, and output by a Prony brake. From these data an input-output, or efficiency curve was plotted. In the tests the input was measured in the same way, and the corresponding output read from the curve. Finally the power necessary to drive the shafting was previously determined in each case, and deducted from the results, giving the net power required to drive the machine.

Second, material: The material cut consisted of blocks of gray cast-iron. These blocks were all cast in the University foundry, from the same pattern. The blocks used in the two machines for corresponding tests were from the same heat. They were weighed when put in the machines, and again when taken out, to determine the amount of metal cut. To be exact the blocks were 16x12x3½ inches, with two leveling lugs cast on the bottom, and weighed approximately 180 pounds apiece.

Third, tools: The cutting tools used were made in pairs from the same bar of Poldi steel. A grinder was so arranged that its table could be set to give automatically any desired lip or clearance angles. Whenever a tool was reground its mate was also reground, and after grinding the angles were carefully tested to gages. Tools of the same pair were used in the two machines for corresponding tests, and care was taken to keep the amounts cut by the two tools equal.

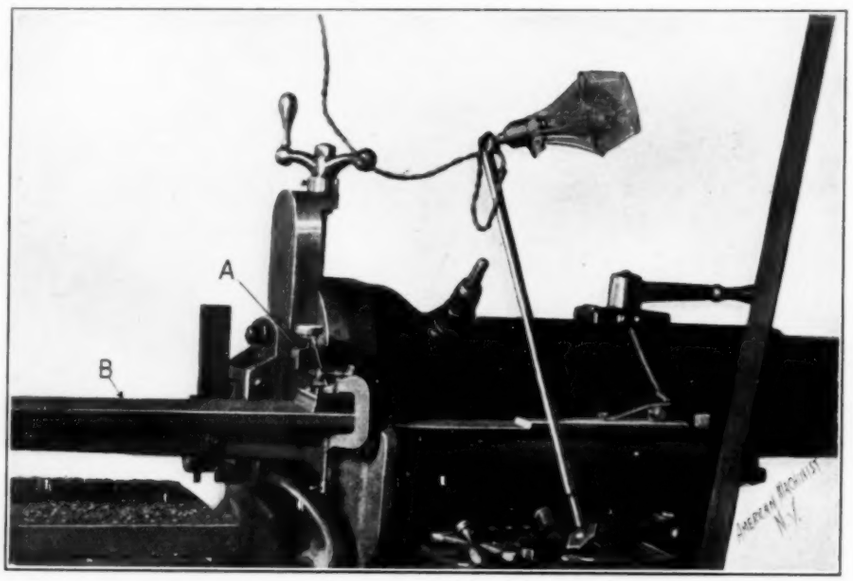


FIG. 3. ARRANGEMENT FOR DEFLECTION TESTS

Fourth, measuring instruments: The same gages, micrometers, surface-plates and other instruments were used for corresponding measurements on the two machines, and these instruments were used for no other purpose while the tests were in progress. Automatic stroke counters kept track of the number of strokes made by each ram and these, as well as the weights of metal cut, were kept as nearly equal as possible.

Fifth, order of tests: Duplicate tests were run in all cases, and where it was

Conditions of Test.		Horse Power Required to Drive Machine.					
		First Set.		Second Set.		Third Set.	
		V	□	V	□	V	□
Machine Running Without Cut.		0.22	0.18	0.12	0.13	0.13	0.14
Cut 0.3125 inch	Feed 0.035 inch	3.18	3.55	2.91	2.62	2.67	2.60
Cut 0.3125 inch	Feed 0.028 inch	2.51	2.88	2.42	2.30	1.94	2.10
Cut 0.3125 inch	Feed 0.021 inch	2.11	2.42	1.89	1.75	1.59	1.70
Cut 0.25 inch	Feed 0.035 inch	2.29	2.55	2.24	2.23	1.97	2.01
Cut 0.25 inch	Feed 0.028 inch	1.93	2.04	1.93	1.84	1.67	1.70
Cut 0.25 inch	Feed 0.021 inch	1.64	1.82	1.56	1.37	1.37	1.39
Cut 0.1875 inch	Feed 0.042 inch	1.72	1.92	1.81	1.81	1.63	1.70
Cut 0.1875 inch	Feed 0.035 inch	1.47	1.66	1.58	1.50	1.48	1.51
Cut 0.1875 inch	Feed 0.028 inch	1.26	1.37	1.37	1.26	1.17	1.27
Cut 0.125 inch	Feed 0.056 inch	1.38	1.69	1.61	1.48	1.51	1.62
Cut 0.125 inch	Feed 0.049 inch	1.22	1.52	1.44	1.37	1.36	1.46
Cut 0.125 inch	Feed 0.042 inch	1.09	1.27	1.33	1.26	1.23	1.30

TABLE 1. RESULTS OF POWER TESTS.

impracticable to run them simultaneously, a test on one machine was immediately followed by a corresponding test on the other.

Classification of the Tests

The tests run may be classified under five heads: First, a comparison of the power required to run the two machines on cuts of the same depths and feeds; second, a comparison of the amounts the mass of figures, but it may be worth while to state that no extreme variation of more than 2 per cent. was found in any one test, and very few of more than 1 per cent.

In the power and deflection tests the results are divided into three sets. The first set was made on the machines as received from the makers and set up; the second and third sets consisted of tests exactly corresponding to those of the first

Cut.	Feed.	Machine.	First Set.				Second Set.				Third Set.			
			Begin. of Stroke.		End of Stroke.		Begin. of Stroke.		End of Stroke.		Begin. of Stroke.		End of Stroke.	
			Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert	Hor.	Vert.	Hor.	Vert.	Hor.
0.25 ″	0.028″	V gibs	0.00183″	0.00397″	0.00157″	0.0007 ″	0.0015 ″	0.00473″	0.00375″	0.00586″	0.00154″	0.01021″	0.00375″	0.01293″
		Sq. gibs	0.00527″	0.00087″	0.00453″	0.00493″	0.00514″	0.00075″	0.00614″	0.00504″	0.004 ″	—0.00084″	0.00882″	0.00536″
0.25 ″	0.021″	V gibs	0.00273″	0.00337″	0.0039 ″	0.0009 ″	0.00111″	0.00361″	0.00375″	0.00539″	0.00111″	0.009″	0.0025″	0.01068″
		Sq. gibs	0.00447″	0.00067″	0.0039 ″	0.0032 ″	0.00453″	0.00086″	0.00514″	0.00486″	0.004″	—0.00057″	0.00761″	0.00482″
0.1875″	0.035″	V gibs	0.00167″	0.00388″	0.00457″	0.005 ″	0.0015 ″	0.00521″	0.00457″	0.00686″	0.00135″	0.01057″	0.00295″	0.01178″
		Sq. gibs	0.0049 ″	0.00052″	0.00548″	0.00633″	0.005 ″	0.00048″	0.00985″	0.00361″	0.00466″	—0.00111″	0.01018″	0.00546″
0.1875″	0.028″	V gibs	0.00073″	0.00342″	0.00272″	0.0042 ″	0.00134″	0.00411″	0.00364″	0.00514″	0.00114″	0.00964″	0.00253″	0.01007″
		Sq. gibs	0.00382″	0.00043″	0.00383″	0.00457″	0.00455″	0.00036″	0.00739″	0.00318″	0.00455″	—0.00109″	0.00859″	0.00478″
0.125 ″	0.049″	V gibs	0.006 ″	0.0022 ″	0.002 ″	0.0022 ″	0.00138″	0.00346″	0.0035 ″	0.00361″	0.00207″	0.00986″	0.00296″	0.01186″
		Sq. gibs	0.005 ″	0.0007 ″	0.0061 ″	0.0038 ″	0.005 ″	0.00057″	0.007 ″	0.00253″	0.004 ″	—0.00116″	0.00821″	0.00489″
0.125 ″	0.042″	V gibs	0.001 ″	0.0031 ″	0.0043 ″	0.0049 ″	0.00121″	0.00346″	0.00321″	0.00386″	0.00186″	0.00896″	0.00225″	0.01078″
		Sq. gibs	0.0043 ″	0.0007 ″	0.005 ″	0.0033 ″	0.00475″	0.00039″	0.00743″	0.00304″	0.004 ″	—0.00096″	0.00753″	0.00382″

The "—" (negative) deflections, in the third set, square gibs, indicate that the tool, instead of springing away from the cut, dug in deeper.

TABLE 2. RESULTS OF DEFLECTION TESTS.

rams were deflected out of line by similar cuts; third, a comparison of the wear on the two rams for a given amount of work; fourth, a comparison of the truth of the surfaces produced by the two machines under similar conditions; and fifth, a comparison of the facilities for adjustment offered by the two types of machine. As to the results as tabulated in this article, each is the average of not less than 14 separate readings. It hardly seemed necessary to burden the reader with such a set, but made after the machines had been run 42 days, each machine cutting the same amount, with the same depths of cut and feeds, but without any adjustment of the gibs. During these 42 days the machines were subjected to as heavy cuts as could be given without overloading, in order to make the effects of the wear as marked as possible. The third set followed the second, but in the interim the gibs were readjusted to take up the wear.

In the wear tests the two sets of readings were taken before the first and after the third sets of power and deflection tests. In the surfacing tests, the first set of readings was made at the beginning of the series of tests and the second set after the readjustment of the gibs.

Point of Measurement.	V Machine.	Square Machine.		
		Horizontal Wear.	Vertical Wear.	
			Side No. 1.	Side No. 2.
1 inch from front	0.0016 inch	0.0016 inch	0.0002 inch	0.0001 inch
6 inches from front	0.0010 inch	0.0029 inch	none	0.0001 inch
12 inches from front	0.0005 inch	0.0023 inch	0.0002 inch	0.0001 inch
12 inches from back	0.0002 inch	0.0005 inch	0.0001 inch	0.0002 inch
6 inches from back	none	0.0018 inch	none	0.0002 inch
1 inch from back	0.0004 inch	0.0007 inch	0.0004 inch	0.0001 inch

Approximate number of strokes of ram, 59,000 per machine.
Approximate weight of metal cut, 1,400 pounds per machine.

TABLE 3. WEAR ON RAMS.

Results

Table I gives the results of the power tests. The arrangements for measuring the power are shown diagrammatically in Fig. 2; *a* is the motor, *b* a jackshaft so arranged that it can be belted to either or both of the shaper countershafts at will, *c* is one of the countershafts, and *d* is the shaper. The belts from the jackshaft *b* to the countershafts *c* were tightened equally, and so arranged that either one could be run off and suspended clear of the jackshaft without unlacing it. The belts from the countershafts *c* to the shapers *d* were also tightened equally, and similarly arranged. Before each set of power tests these latter were run off, and the power necessary to drive the jackshaft and countershaft was measured. When the machines were first set up, and again when the gibs were readjusted, the pressure of the gibs was so regulated that the two rams required the same force to move them. This was accomplished by taking out the pins connecting the rams to the yokes, and moving the rams by the pull of a heavy spring balance.

In the deflection tests, an angular casting was bolted to the head of each ram, as shown at *A* in the cut, Fig. 3. The compound rest of a lathe was then clamped to the table and, by means of a tool held in this latter, the casting *A* was faced off on two surfaces, the ram being run back and forth as in regular operation. The angle casting *B* was then bolted to the column in such a position as to clear the knee, table and work. To this piece *B* a Starrett indicator was clamped with its button riding on the surface of *A*. Then by moving the ram back and forth, and by trying various positions for the indicator, the inequalities in the surface of *A* were found and scraped down. In this way two surfaces, one vertical and one horizontal, were secured truly parallel with the line of motion of the ram. Now

if the indicator was clamped to the piece *B* so that its button rode on the vertical surface of *A* at the beginning of the cut, the amount the head of the ram was deflected horizontally out of line on the tool entering the cut could be read directly.

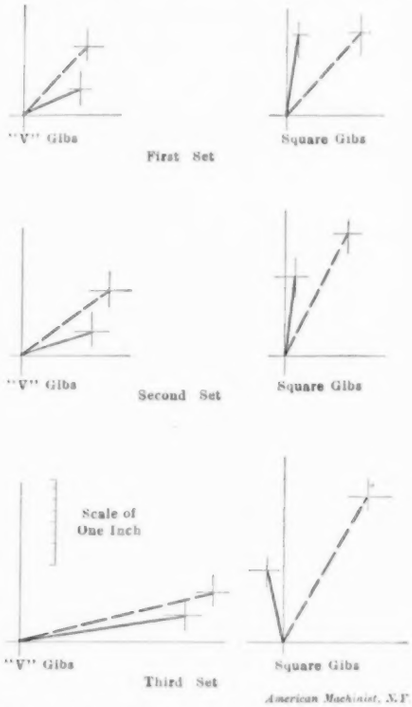


FIG. 4. DIAGRAMS REPRESENTING AVERAGE DEFLECTIONS OF RAMS FOR EACH SET SCALE OF DIAGRAMS AS ORIGINALLY DRAWN, 1 INCH = 0.005 INCH ACTUAL DEFLECTION

Similarly the amount of the vertical deflection at the beginning and the vertical and horizontal deflections at the end of the cut were ascertained. The results of the deflection readings are given in Table 2, and the deflections are plotted graphically in the diagrams Fig. 4. In these latter the solid lines show the amount the tool was thrown out of line at the beginning, and the broken lines at the end of the cut.

In the wear tests templet gages were made of the form shown in Fig. 5 to fit loosely over the rams. By inserting a graduated wedge between the gages and the ram surfaces the amount of this looseness could be determined. The wedge was made with a taper of one in a hundred and graduated in tenths of an inch. Thus every division that it entered indicated a space of 0.001 inch. Table 3 gives the results of these measurements, the gages having been applied at points 1 inch, 6 inches and 12 inches from the front ends and the same distances from the back ends of the rams.

In the surfacing tests the machines were made to take a very light scraping cut (the same for both machines) over the surface of the block, with newly ground tools. A surface plate was then applied to the surface of the block; in all cases the highest spot was found to be in the center of the block. Shims of cigarette paper were then inserted at the corners of the block, until the surface plate rested evenly without rock. These shims were then measured by means of an ordinary micrometer caliper. Table 4 gives the results of these measurements.

As to the results; in the power tests it will be noted that in the first set the square-gibbed machine ran 18 per cent. lighter without cut than the V-gibbed machine. Under cutting conditions, however, the V-machine showed an advantage of from 5 per cent. to 20 per cent. Between the first and second sets the V-machine eased up in the lighter cuts, but ran harder on the heavy cuts. The square machine, on the other hand, eased up all along the line. So in the second set we find the square machine showing an advantage of from 4 per cent. to 12 per cent. In the third set after readjustment the V-machine again shows an advantage of from 1 per cent. to 7½ per cent.

In the deflection tests the V-machine showed an all-round advantage in the first set, but the square machine had the advantage in the horizontal deflections of the second and third sets. On the other hand, the square machine increased its *vertical* deflections and could not be brought back, although a special effort was made to do so. It might have been accomplished if the top gibs had been so tightened that the power needed to move

Readings of	Machine.	Number of Papers.	Thickness.
1st set.	V gibs	1	0.0025 inch
	Square gibs.	3	0.0075 inch
2d set.	V gibs	none	
	Square gibs.	7	0.0175 inch

TABLE 4. SHIMS REQUIRED TO LEVEL SURFACE PLATE.

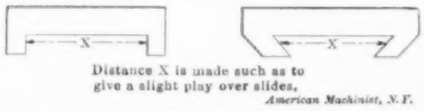


FIG. 5. GAGES FOR RAM MEASUREMENTS

the ram had been materially increased, but the tests were purely comparative and this would have put the two machines on an uneven footing. As it was the top gibs were tightened so that they took nearly all of the frictional resistance—very much more than the side gibs.

In the wear tests, Table 3, the surface of the V gibs showed much less wear than the side surfaces of the square gibs. It is somewhat difficult to compare these fairly, as the wear on the V-gibs would affect both vertical and horizontal play of the ram, but it may be noted that the vertical wear, that is the wear on the top and bottom of the square slides, is singularly light, being measurable only in ten-thousandths of an inch. The value of these measurements seems rather doubtful as the deflection tests would seem to give a much better indication of the effect of wear on the two machines.

In the surfacing tests it is natural that the square machine, which showed markedly larger vertical deflections, should give the poorer results. On the first set of readings the corners of the surface produced by the V-machine needed 0.0025 inch of shims; that produced by the square machine needed 0.0075 inch. On the second set the surface plate rested fair and square on the surface produced by the V-machine, showing no appreciable hollows or humps, while on that produced by the square machine 0.0175 inch of shims was required to bring it to an even bearing.

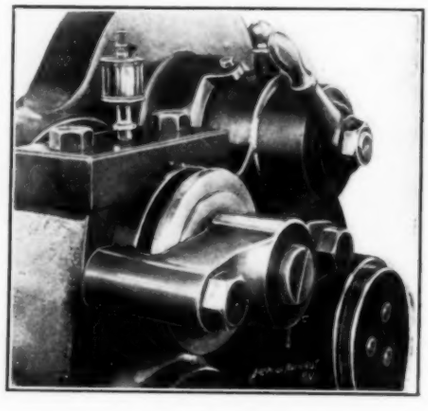
As to the ease of adjustment, the advantage would seem to rest with the V-machine. On it only one gib has to be adjusted to take up both vertical and horizontal wear, while on the square machine it is very difficult to bring both top and side gibs to an even adjustment, it being obviously possible to bind the ram with one without getting all the shake out of the other.

In conclusion it may be said that the two machines are still in the University shops running on duplicate work and that it is intended to give them a further set of comparative tests after a much longer period of wear; say a year from the last set.

A Handy Index Plate on a Large Lathe

By E. A. Dixie

The division plate shown in the halftone is mounted on the rear end of the spindle of a 50-inch Bement crank-shaft lathe. The plate is about 8 inches in diameter divided to degrees, which makes the spaces between graduations about 1/16



A HANDY INDEX PLATE

inch. It is frictionally secured to the spindle so that it can be moved when necessary without moving the spindle itself. It is used for laying off keyways, etc., and for this it has been found very handy.

Two English Machine Tools

By Frank C. Perkins

The accompanying illustration shows an English 20-inch stroke slotting machine of substantial design and construction fitted with powerful gearing, designed to permit the use of high-speed steel to its full advantage. The upright and bed are in one casting of box section, the whole being well ribbed to eliminate vibration.

The flywheel and cone pulley are placed at right angles to the frame. The machine is fitted with compound slides and a circular table, the latter having machined radial T-slots and a deep channel to hold lubricants. The center is bored to receive a 2-inch Whitworth center bolt.

The table is revolved by a steel worm, which is arranged to drop out of gear by means of an eccentric shaft to enable the table to be quickly revolved in either direction by hand. This arrangement effects a great saving of time when setting work. A dividing apparatus is provided so that the sides of a square or polygon, can be accurately slotted.

All the feed motions are intermittent, timed to occur between cutting strokes, and are derived from a feed cam acting through rocking levers to ratchet feed, the variation of feed being obtained by the different throw of the ratchet pawl. All feed is disengaged by means of friction clutches on the feed screws.

The ram works in long continuous V-slides, which can be adjusted from both sides. It is balanced at the back of the frame and fitted with a quick return motion. The stroke can be quickly adjusted and is provided with an index for registering the different lengths of stroke. The relative position of the ram and work is readily altered from the front of the ram.

The maximum length of the stroke of the machine is 20 inches and it will admit castings of 6½ feet in diameter. The hight of the work may be 2 feet 9 inches and the longitudinal traverse is 3 feet, while the cross traverse measures 3 feet 4 inches and the cutting speed is 20 feet per minute. The gear ratio of this machine is 10:1, while its approximate weight is 3 tons. It is built by Holroyd & Co., Ltd., Milnrow, England.

The other illustration, Fig. 2, shows a new and interesting type of English motor-driven wall radial drilling machine. The spindle has an automatic feed by means of worm and worm wheel, or can be fed by hand if desired.

The saddle is traversed rapidly along the arm by means of rack and pinion, the motion being controlled from the saddle itself. The arm fits into wall plate and has lock nuts to hold the arm in position. The wall plate is webbed, and has cored holes for bolting to wall or girder.

This machine is driven by a slow-speed semi-inclosed motor connected by Renold's silent chain to speed box. The starting switch and cut-off are arranged so that the whole machine is self-contained. The speed box has eight changes of speed, four of which are obtained instantly by moving lever, and the other four by simply putting in double gear. This machine is made with balanced spindles, rack feed, and reversing motion for tapping when required.

On this machine the maximum distance from the center of the arm to the center of the spindle is 6 feet 0 inches, while the traverse of the head is 4 feet 7 inches. The diameter of the spindle is 2½ inches and its range of spindle is 14 inches. The approximate weight is 3500 pounds, and the approximate wall space occupied is 60 inches wide by 54 inches deep. The power of motor used is 5 brake-horsepower.

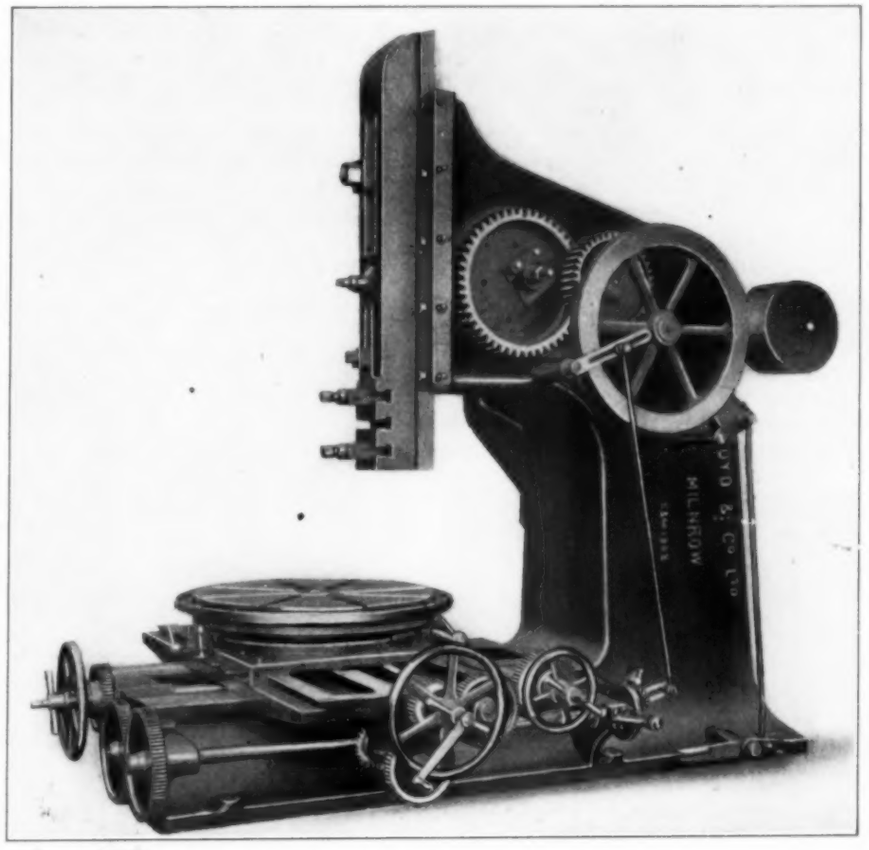


FIG. 2. AN ENGLISH SLOTTER

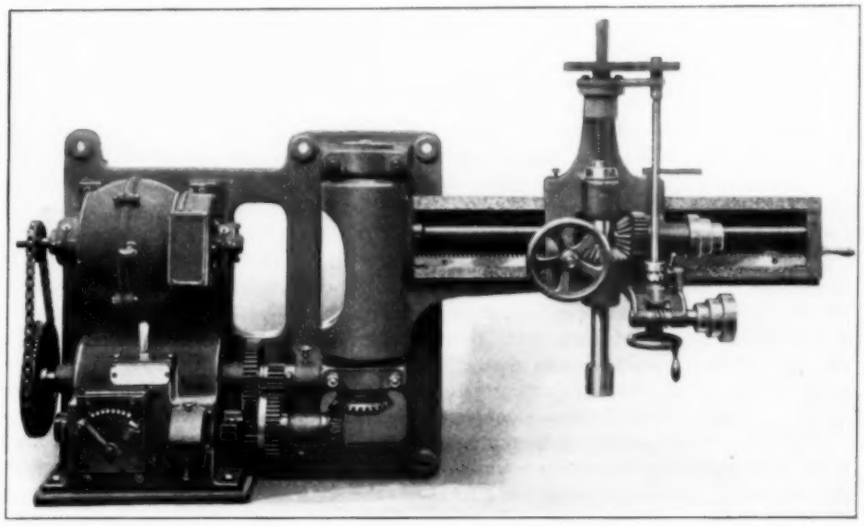


FIG. 1. UNIQUE WALL RADIAL DRILL

Alternating Current Electric Motors

Distinguishing Features of Construction, Characteristics of Operation and Uses of the Squirrel Cage, Slip Ring Induction and Synchronous Motors

BY SNOWDEN B. REDFIELD

There are three kinds of alternating-current motors in general commercial use. These motors are of the following types: The "squirrel cage," the "slip ring" and the "synchronous." The squirrel-cage and slip-ring motors are known as induction motors and are in most cases designed to operate on polyphase circuits. Most alternating current circuits of the present day are of the polyphase type and it may be said that the electric current is transmitted in a series of pulsations, these pulsations following each other in regular order in the different phases or legs of the circuit. In most circuits there are three phases and this is called a three-phase circuit. If there are but two phases, it is called a two-phase circuit. If there is only one phase, it then is known as a single-phase circuit and cannot be called polyphase.

The rotating part of an induction motor is generally called the "rotor" and the

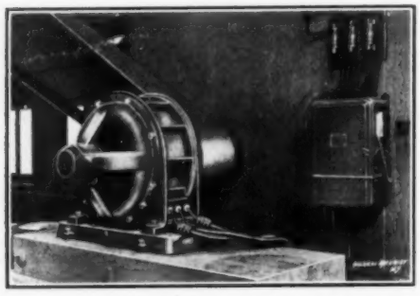


FIG. 1. GENERAL ELECTRIC FORM K, SQUIRREL-CAGE INDUCTION MOTOR

stationary part is called the "stator." Both of these parts are made up of soft-iron laminations, which carry the windings. The laminations are so constructed as to prevent the formation of eddy currents through the iron parts, as these eddy currents are a direct source of loss and do no useful work whatever.

The Squirrel-cage Motor

Fig. 1 shows a squirrel-cage motor, with starting compensator. Its various parts are shown in Fig. 2 A and B.

The most distinguishing feature of the squirrel-cage motor is its rotor, the windings of which are in the form of copper bars which are short-circuited upon one another by means of rings at the ends of the rotor. This construction gives rise to the name of "squirrel cage," as it remotely resembles the small wire wheels which are usually seen on cages for holding pet squirrels. The wire windings of the stator are so arranged that the current pulsations follow one another in such a manner as to produce magnetic fields in the soft-iron laminations which are continually changing their position, giving rise to an actual rotation of the magnetism. This rotation of the magnetism in the stator induces a rotating magnetism in the rotor, which in turn gives rise to the generation of alternating currents in the bars of the rotor.

The combined action of the rotating magnetism and the current in the bars causes the bars and the soft-iron core to rotate in the same direction as the magnetism, but at a slightly slower speed. If the motor is doing no useful work and there is very little resistance to the rotation of the rotor, the speed of this rotor will be very nearly equal to the speed of rotation of the magnetism which is called the "synchronous speed." In this case, as the bars are moving almost as fast as the magnetism, there is very little current generated in the bars. If, however, the motor is called upon to do useful work, the rotor will lag a little in speed, causing the magnetism to pass over the bars at a greater speed, generating a much heavier current in the bars. The heavier the current, the greater the pull and the more work will the motor do. Induction motors are usually designed in such a way that, when the motor is delivering full load, the "slip" will amount to about 3½ per cent. By slip is meant the difference in speed between the rotor and the magnetism.

In order to start a squirrel-cage motor, a transformer or "compensator" (Fig. 3) is used, which is so designed that the voltage of the line may be impressed upon the stator of the motor in a series of increasing steps. By thus gradually increasing the voltage impressed upon the motor, it is allowed to get up to speed without causing such a heavy flow of current as to burn out the parts of the motor.

The Slip-ring Induction Motor

The slip-ring induction motor differs from the squirrel-cage motor principally in the fact that the rotor is wound instead of being composed of straight copper bars. The ends of these windings are brought out to rings (Fig. 2 C) on the shaft of the rotor (hence the name "slip ring") and by means of brushes bearing upon these rings, the induced current in the motor may be passed through external resistance. In order to start a slip-ring motor, a high resistance is placed in series with the rotor and the full voltage is impressed directly upon the stator. The resistance in the rotor circuit prevents the current in the rotor from becoming excessive and this in turn reacts upon the current in the stator in such a way as to reduce its value

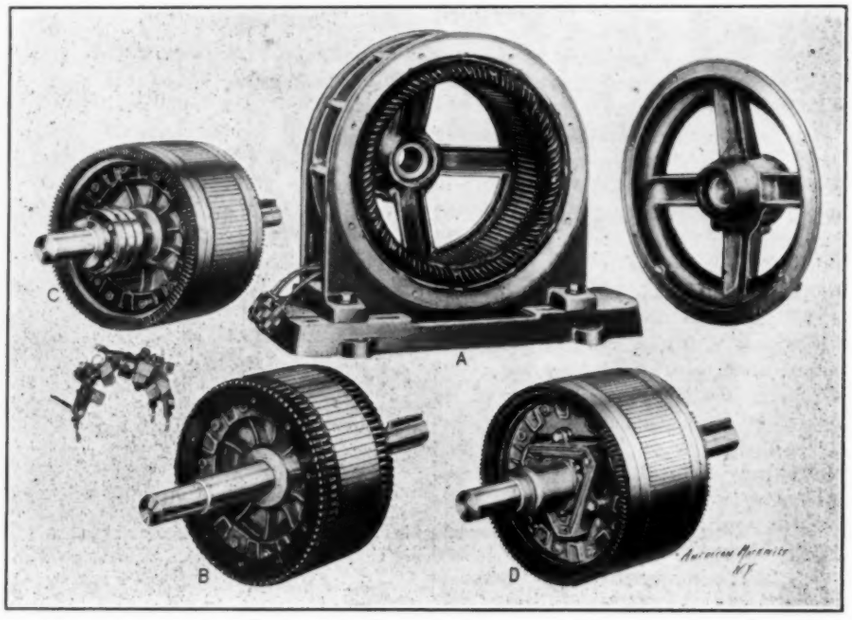


FIG. 2. A—STATOR OF GENERAL ELECTRIC INDUCTION MOTOR. B—SQUIRREL-CAGE ROTOR. C—SLIP-RING ROTOR. D—INTERNAL-RESISTANCE ROTOR. STARTING RESISTANCE INSIDE ROTOR, CONTROLLED BY KNOB AT END OF SHAFT

also. The resistance is controlled and gradually cut out as the motor gains speed, by means of a controller, shown in Fig. 4.

The Synchronous Motor

The synchronous motor is almost exactly like an alternating-current generator. Fig. 5 illustrates a synchronous motor of General Electric manufacture. It is supplied with field magnets which are energized by a direct current from some external source. These field magnets (Fig. 6) usually form the rotating part of the motor, while the armature which receives the regular alternating current remains stationary. Its appearance is very similar to Fig. 2 A. The action of the alternating current upon the armature may be said to produce a series of pulsations of magnetism which cause rotation of the rotor of the motor.

In a synchronous motor there is no slip, but the motor runs at the same speed as the generator if the two machines are of the same construction. The principal peculiarity of the synchronous motor is

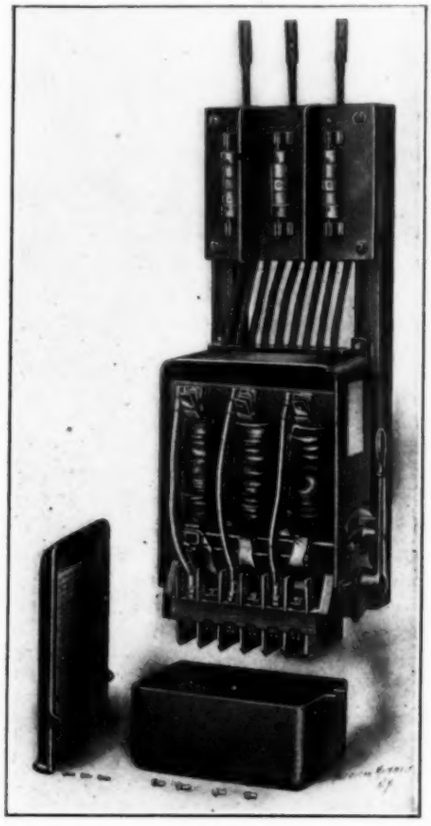


FIG. 3. GENERAL ELECTRIC STARTING COMPENSATOR FOR SQUIRREL-CAGE MOTOR

that it must be started from some external source of power and if it is very greatly overloaded, it will fall out of "step" and stop altogether. There are some manufacturers, however, who by placing auxiliary squirrel-cage windings upon the rotor are enabled to produce a motor which will start itself with from 30 to 50 per cent. of starting torque, or twist.

Characteristics

The principal characteristics of the squirrel-cage induction motor are its simplicity and ruggedness. It is also cheaper than the other forms of alternating-current motor. Its principal objection is its low starting torque. In order to develop full-load torque at starting, the squirrel-cage induction motor will require from 400 to 500 per cent. of full-load current. The reason for this is, that the starting torque is directly proportional to the square of the voltage impressed; or, half the voltage gives one-quarter torque, and as the squirrel-cage motor is started by the impression of reduced voltage, it follows that its starting torque is very small indeed. This small starting torque gives rise to excessive slip during the period of starting and consequently the generation of very heavy current in the parts, as there is no

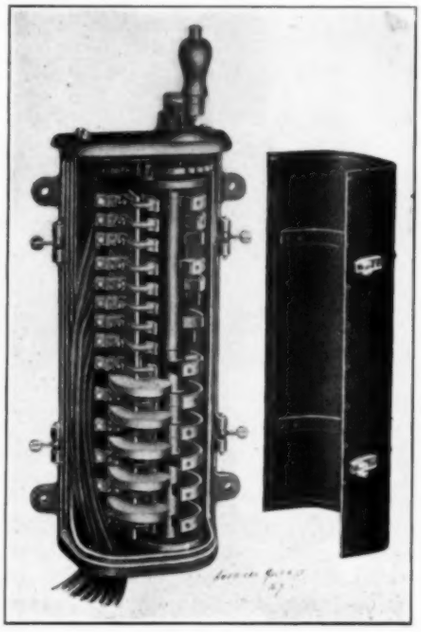


FIG. 4. GENERAL ELECTRIC CONTROLLER FOR SLIP-RING MOTOR

external resistance in circuit with the rotor.

The slip-ring induction motor is slightly more expensive than the squirrel-cage motor, but it has the advantage of giving a very high torque at starting, this torque being developed without excessive in-rush of current. Also by the introduction of variable resistance in the rotor circuit, considerable variation in the speed of the motor may be obtained. This speed variation is, however, produced at a sacrifice of economy, somewhat as is the case when a direct-current motor is reduced in speed by the insertion of resistance in its armature circuit. It, nevertheless, often happens that speed variation is of more importance than economy.

Up to recent years the objection to the synchronous motor was that it is necessary to start it from an external source of power. This feature, as already explained, has now been overcome on the larger units by some manufacturers. It is, however, still necessary to supply a direct current to the field magnets of the synchronous motor and this gives rise to some inconvenience.

The principal advantage of the synchronous motor is its high "power factor." The power factor of an alternating cur-

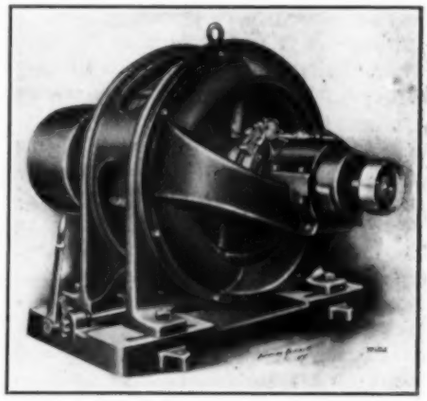


FIG. 5. GENERAL ELECTRIC SYNCHRONOUS MOTOR

rent is the ratio of the actual power developed to the apparent power which would be obtained by the multiplication of the voltage by the amperes. In nearly every alternating-current circuit, the pulsations of current are not in exact step or "phase" with the pulsations of voltage, and it is only that part of the current pulsations which are in step with the pulsations of voltage, which develop useful power. The other portion of the current gives rise to what is known as an "idle current" and its effect is to produce heating in the parts of the machinery and the transmitting line without doing any useful work at all. This idle current then reduces the available capacity of the generating station and also of the transmitting line and for this reason it is advisable to keep the power factor as high as possible, and so reduce the idle current to a minimum.

The synchronous motor does not produce any loss in power factor, and for this reason it has a distinct advantage. It also has the further faculty of being able to *improve* the power factor of an existing electric line by the over-excitation of its field magnets. For this reason it is often used on circuits where the existing power factor is low and where the capacities of the generating station and the line are beginning to be entirely used up.

General Uses

The squirrel-cage induction motor is used in most places where infrequent starting and low starting torque are required. Its general ruggedness makes it particularly adaptable to places where it is liable to receive rough usage, as there being no commutator or slip rings, these sources of trouble are avoided.

The slip-ring induction motor is used where frequent starting and high starting torque are required. It lends itself particularly well for elevators and hoists and also for pumps and air compressors if automatic starting and stopping control are required. Fig. 7 shows a hoist equipped with a General Electric slip-ring motor.

The synchronous motor is often used on large units where infrequent starting and high power factor are wanted. There are many power companies which strongly advocate the use of synchronous motors wherever possible so as not to further reduce the power factor of their existing line and in many cases to improve the existing power factor. Owing to the almost uniform character of the load of an air compressor, this machine lends itself especially well for the use of synchronous motors when placed on electric lines for the purpose of raising their power factor. An instance of this is at Dos Estrellas mines of El Oro Mining and Development Company, in Mexico. Here there are two 200-horsepower direct-connected air compressors with synchronous motors operating on the Necaxa power line. The synchronous motors on these units are started by an auxiliary 50-horsepower slip-ring induction motor, by means of sliding gears. Fig. 8 illustrates one of these units. Another instance of this is in the United States navy yard, at Norfolk, Va., where there are two 550-horsepower direct-connected air compressors with synchronous motors of the self-starting type, being installed. In both these instances, the synchronous motors are being used directly to improve the power factor of the existing power lines and thus increase the capacity of the generating station and the transmitting wires.

Government Purchase of Coal on Heating Value Basis

The fuel bill of the United States Government now aggregates about $10,000,000 per annum. The saving made by the reduction of ash alone, through buying coal on a heating-value basis, is some $200,000. The above information is furnished by a bulletin of the technologic branch of the United States Geological Survey, just issued, in which are assembled results of the Government's purchase of coal under heat-value specifications for the fiscal year 1907-8.

At the present time 40 departmental buildings in Washington, the Panama railroad, more than 300 public buildings throughout the country, navy yards and Government arsenals are buying their coal under specifications, the essential provisions of which fix the amount of ash and moisture. Premiums are paid for coal better than the specified standard; deductions are made for coal inferior to such standard. On this basis the Government is getting what it pays for, and is paying for what it gets.

The advantages of this system of purchasing coal are briefly summarized as follows:

"Bidders are placed on a strictly competitive basis as regards quality as well as price. This simplifies the selection of the most desirable bid and minimizes controversy and criticism in making awards.

"The field for both the Government and dealers is broadened, as trade names are ignored and comparatively unknown coals offered by responsible bidders may be accepted without detriment to the Government.

"The Government is insured against the delivery of poor and dirty coal, and is saved from disputes arising from condemnation based on the usual visual inspection.

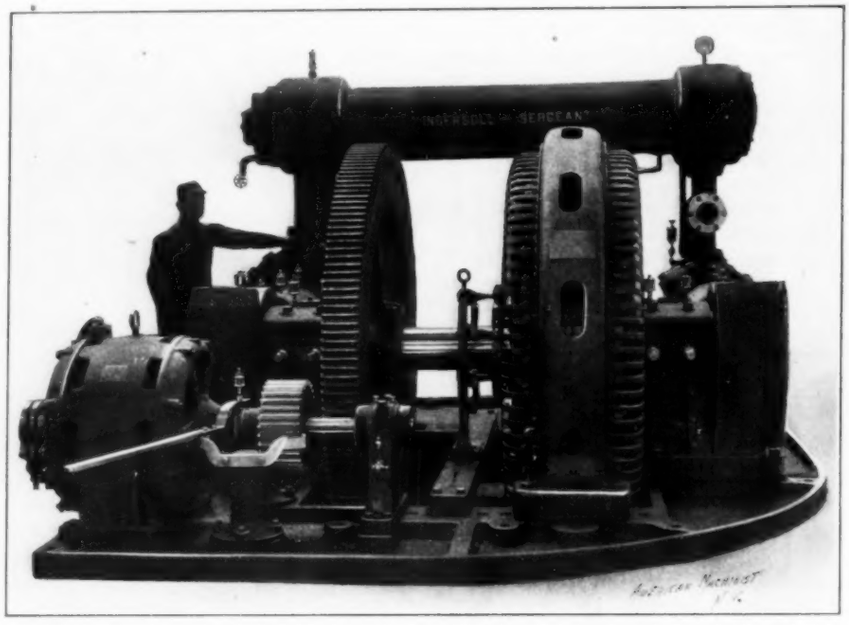


FIG. 8. WESTINGHOUSE SYNCHRONOUS MOTOR DRIVING INGERSOLL-SERGEANT AIR COMPRESSOR: EQUIPPED WITH AUXILIARY SLIP-RING INDUCTION STARTING MOTOR

"Experience with the old form of Government contract shows that it is not always expedient to reject poor coal, because of the difficulty, delay and cost of removal. Under the present system rejectable coal may be accepted at a greatly reduced price.

"A definite basis for the cancellation of contract is provided.

"The constant inspection and analysis of the coal delivered furnishes a check on the practical results obtained in burning the coal."

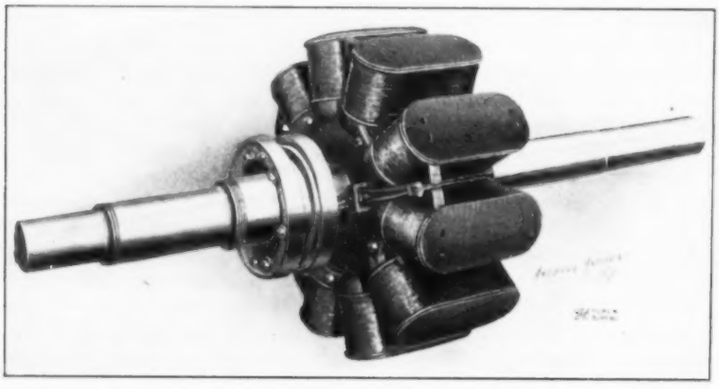


FIG. 6. REVOLVING FIELD MAGNETS OF GENERAL ELECTRIC SYNCHRONOUS MOTOR

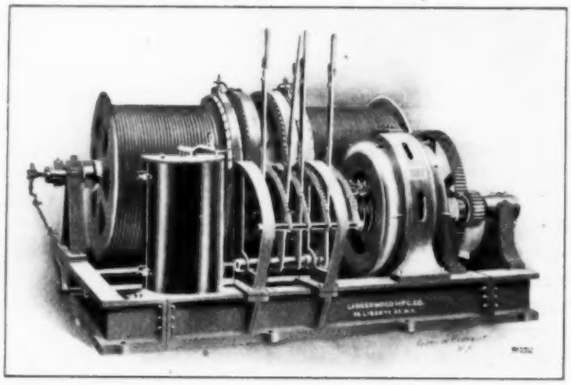


FIG. 7. ELECTRIC HOIST EQUIPPED WITH GENERAL ELECTRIC SLIP-RING INDUCTION MOTOR

Experiments on Forces Acting on Twist Drills—I

To Determine Twisting Moment and Feeding Force with Drills of Various Diameters, at Various Feeds and Speeds, in Cast Iron and Steel *

BY DEMPSTER SMITH AND R. POLIAKOFF

The experiments recorded below were made with an ordinary twist drill. It is hoped that they may prove of service to the machine designer and user alike. They represent part of the work done during the last three years by the mechanical-engineering students in the machine-testing laboratory of the Manchester Municipal School of Technology. If these results should have any value, the thanks of the engineering public must be accorded to the authorities of that institution for all the facilities to make the experiments, and their permission to reproduce the same, and also to Sir W. G. Armstrong, Whitworth & Co., of Manchester, for their generosity in providing free of charge all the drills from ¾ to 3 inches diameter in duplicate and the material used to operate upon.

Experiments with the First Apparatus

The experiments had for their object:

(*a*) To determine the twisting moment required for drilling with different diameters of twist drills at various speeds and feeds in cast iron and steel.

(*b*) The feeding force required for the various conditions mentioned in (*a*).

(*c*) To ascertain the twisting force required to enlarge a hole (which had previously been opened with a drill of smaller diameter) at different rates of feed on cast iron and steel.

(*d*) The corresponding feeding force required under the circumstances instanced in (*c*).

Ordinary commercial A. W. high-speed steel twist drills of ¾, 1 and 1½ inches diameter were used throughout these trials. The drills were ground on a twist-drill grinding machine and the point thinned to about half the thickness of the web. Particulars of the drills are given in Table 3.

The cast iron operated upon was of medium hardness and had the skin removed. The steel was Whitworth's (fluid-pressed), of medium hardness, having 0.29 per cent. carbon and 0.625 per cent. manganese.

Description of Apparatus Used in the First Series of Experiments

The first series of experiments was made on an 18-inch center screw-cutting lathe by Sir W. G. Armstrong, Whitworth & Co., Manchester, where the work was held in the chuck and rotated with it. The arrangement is shown in Fig. 1. The lathe was driven by a 120-horsepower direct-current, shunt-wound motor. A large air-cooled rheostat connected to the main circuit between the line and brushes allowed of the speed being varied from 100 to 300 revolutions per minute. The motor drove onto a countershaft whereon was mounted a three-step cone similar to that on the lathe spindle. A farther reduction of speed could be obtained through the double and treble gears in the machine, the ratio of which was 14.9 and 42.5 to 1, respectively. The combined arrangement thus permitted of the speed being varied from 1.5 to 450 revolutions per minute. A counter fixed to the tail of the spindle indicated the revolutions made by the work.

The stand *A*, bolted to the bed of the lathe, supports the drill close to the work. The drill is quite free to slide in the bearing provided in the stand. Suitable hardened-steel bushes are used for the various sizes of drills. A small spindle or socket *B* receives the tang end of the drill and the thrust on the same is taken by the knife-edged lever *C* and a diaphragm dynamometer fitted to a cast-iron block which is bolted to the top slide rest.

The arm *D* is clipped and cottered at one end to *B*, while the other extremity resting on a scale pan prevents the drill from rotating. As the arm advances with the drill and the scale pan is stationary the former is fitted with a knife-edged roller to reduce side twist on the drill due to friction. The force exerted on the pan when multiplied by the length of the arm gives the twisting moment on the drill. On the engagement of the screw-cutting feed mechanism a definite advance is given to the saddle and drill per revolution of the work. The diaphragm dynamometer is similar to that shown in section in Fig. 6 and described in the second apparatus. The speed in the ordinary force trials was kept constant at 10 revolutions per minute for each diameter of drills. The revolutions were observed on the counter at the end of the lathe spindle and a tachometer on the motor.

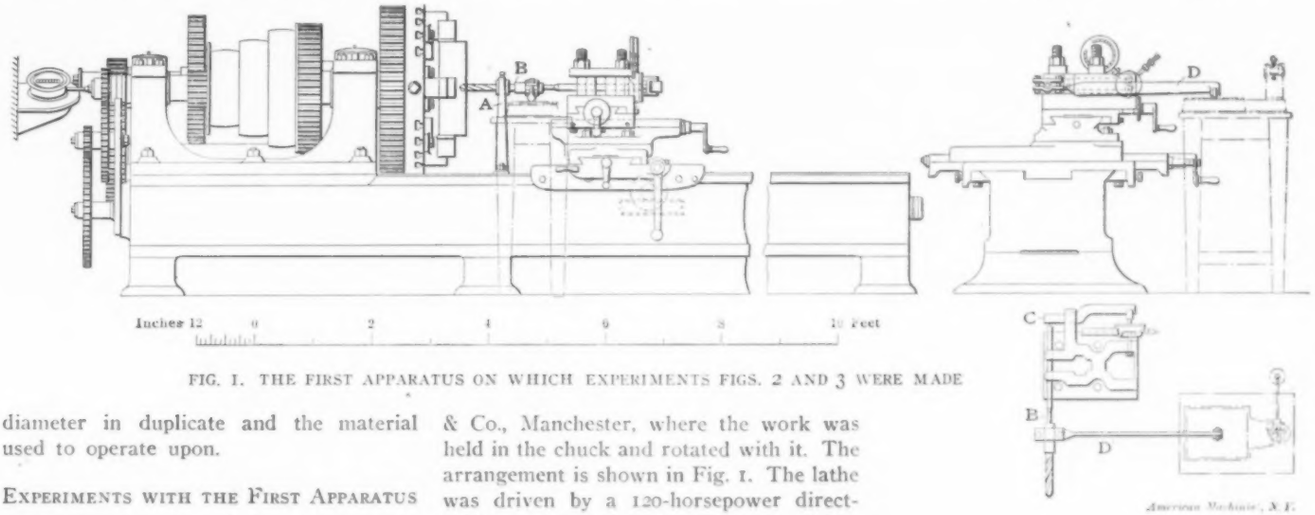


FIG. 1. THE FIRST APPARATUS ON WHICH EXPERIMENTS FIGS. 2 AND 3 WERE MADE

Power observations were made at the commencement of these trials, but as the work done in performing the cut was so small in comparison with that required to overcome friction, the accuracy of the results could not be relied on and the readings were consequently discontinued. No perceptible difference was observed in the twisting moment and end-pressure with the variation of speed; that is, the cutting horsepower for a given diameter of drill and feed was directly proportional to the speed.

As some of these experiments have been repeated in the second set of trials the

*Condensed from a paper presented to the Institution of Mechanical Engineers.

values have not been tabulated, but are given in diagrammatic form with different forms of spots for each set on Figs. 2 and 3.

RESULTS OF EXPERIMENTS WITH FIRST APPARATUS

The results obtained in these experiments may be indicated as follows:

The twisting moments in foot-pounds for trials (*a*) have been plotted as ordinates on a base of feed in inches per revolution of the work in Fig. 2. The diameter of the drill and material operated upon are distinctly marked on the diagram and a full line drawn through the mean of the spots.

The twisting moments for the opening-out experiments (*c*) have also been plotted as ordinates on Fig. 2, and are distinguished by open spots inclosed by a circle and a dot-and-dash line drawn through the mean of them. These experiments appear to indicate that the twisting moment with feed follows a linear law which can be expressed by the following equations:

Trials (*a*) on medium cast iron;

$T = 1220\,t + 2.5$ for ¾-inch drill, (1)
$T = 1840\,t + 7.5$ for 1-inch drill, (2)
$T = 3640\,t + 22.5$ for 1½-inch drill. (3)

The values are represented by strong full lines in Fig. 2.

An equation embracing the whole;

$$T = 12(d^2 - 0.35) + (500 + 1350\,d^2)\,t \quad (4).$$

Taking a more approximate, but more simple expression for formula (4);

$$T = (1800\,t + 9)\,d^2. \quad (4a)$$

For the opening-out trials (*c*) on cast iron

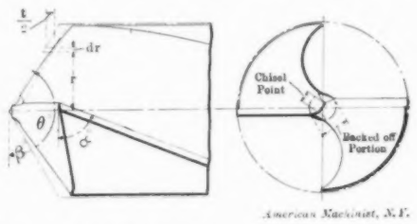


FIG. 4. THREE-INCH DRILL IN THE SECOND APPARATUS

the twisting moment is given by the formula;

$$T = 2812\,t + 17.5 \text{ opening } \tfrac{3}{4}\text{-inch hole to } 1\tfrac{1}{2}\text{-inch diameter,} \quad (5)$$

which is represented on Fig. 2 by a full line.

The twisting moment in trials (*a*) on steel follows a similar law to the cast iron. An expression for each size of drill is given below:

$T = 1530\,t + 15$ for ¾-inch drill, (6)
$T = 3850\,t + 18$ for 1-inch drill, (7)
$T = 7800\,t + 48$ for 1½-inch drill. (8)

These equations are represented by the full line drawn on Fig. 2.

An approximate expression for the above which is near enough for all practical purposes is;

$$T = (3200\,t + 20)\,d^2. \quad (9)$$

For the opening-out trials (*c*) on steel (not plotted);

$T = 1590\,t + 6$ opening ¾-inch to 1-inch. (10)
$T = 3325\,t + 29$ opening 1-inch to 1¼-inch. (11)
$T = 8025\,t + 31$ opening ¾-inch to 1½-inch. (12)

where

T = Torque in pounds-feet,
d = Diameter of the drill in inches,
t = Feed in inches per revolution of the drill,
P = End thrust in pounds.

These symbols have the same meaning in that which follows: That the torque should be proportional to the square of the drill diameter and approximately proportional to the feed is what one would expect, since it was shown by Dr. J. T. Nicolson in his "Experiments with a Lathe Tool Dynamometer" that the cut-

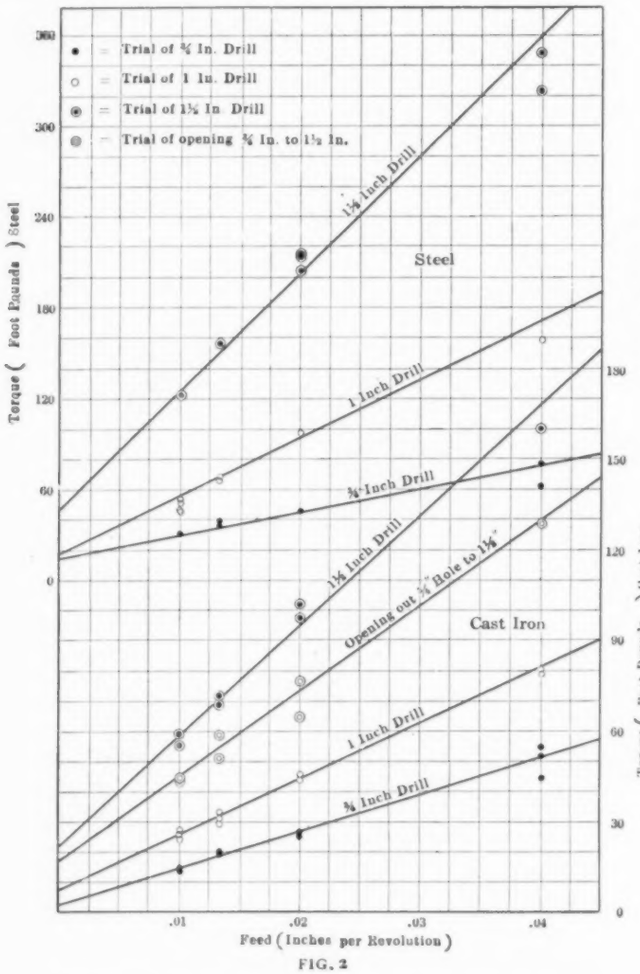

• = Trial of ¾ In. Drill
○ = Trial of 1 In. Drill
◉ = Trial of 1½ In. Drill
◎ = Trial of opening ¾ In. to 1½ In.
1½ Inch Drill
Steel
1 Inch Drill
¾-Inch Drill
1½ Inch Drill
Opening out ¾ Hole to 1½
Cast Iron
1 Inch Drill
⅝ Inch Drill
Torque (Foot Pounds) Steel
Torque (Foot Pounds) Cast Iron
Feed (Inches per Revolution)

FIG. 2

VARIATIONS OF TORQUE WITH FEED WHEN OPERATING ON MEDIUM STEEL AND MEDIUM CAST IRON

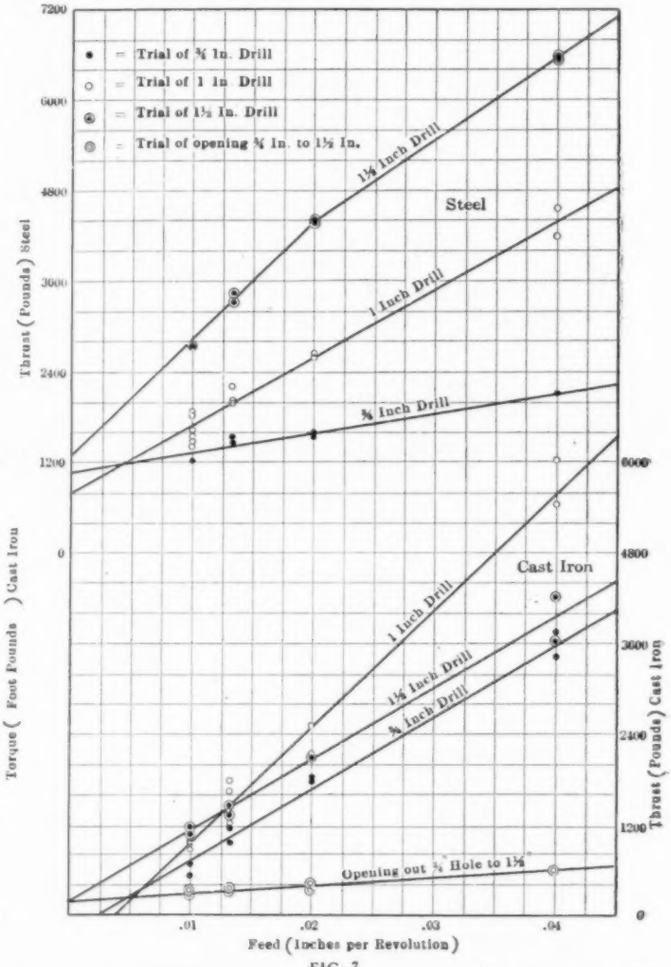

• = Trial of ¾ In. Drill
○ = Trial of 1 In. Drill
◉ = Trial of 1½ In. Drill
◎ = Trial of opening ¾ In. to 1½ In.
1½ Inch Drill
Steel
1 Inch Drill
⅝ Inch Drill
Cast Iron
1 Inch Drill
1½ Inch Drill
⅝ Inch Drill
Opening out ¾ Hole to 1½
Thrust (Pounds) Steel
Thrust (Pounds) Cast Iron
Feed (Inches per Revolution)

FIG. 3

American Machinist, N.Y.

VARIATIONS OF THRUST WITH FEED WHEN OPERATING ON MEDIUM STEEL AND MEDIUM CAST IRON

ting force was directly proportionate to the depth of cut and almost proportionate to the feed for any given cutting angle of tool; and farther, that for any given traverse the cutting pressure should be proportional to the angle.

Now, in twist drills the cutting angle varies right across the face from about 65 degrees at the outside to about 90 degrees at the web. On examination it was found that the value of the average angle relative to the diameter of the drill was practically the same for all drills used.

Neglecting the chisel point the average cutting angle may be assumed to be in the middle of the lip, i.e., at $\frac{r}{2}$ from the center of the drill. Taking the cutting pressure f proportional to the area of cut (that is the difference due to the traverse has been neglected), then the area of cut on each lip $= \frac{r\,t}{2}$ and since there are two lips in the drills under consideration

$$T = 2f\frac{(r\,t)}{2}\,\frac{r}{2} = \frac{f\,t\,r^2}{2},$$

but

$$r^2 = \frac{d^2}{4},$$

$$\therefore\ T = \frac{f\,t\,d^2}{8}.$$

The opening-out trials (c) might be treated in the same way, but it is evident from the above that as the ratio of the holes varies, so will the cutting angles and consequently the cutting pressure. This then would necessitate an equation involving the cutting angle. This is discussed more fully, however, in the second set of experiments.

The end thrust P on the drills for trials (b) has been plotted as an ordinate on a base of feed t in inches per revolution of the work in Fig. 3.

For medium cast iron the laws are approximately,

$P = 95{,}600\,t - 250$ for ¾-inch drill, (13)
$P = 93{,}400\,t + 180$ for 1-inch drill, (14)
$P = 154{,}000\,t - 600$ for 1½-inch drill. (15)

The equations are represented by the full lines in Fig. 3;

$P = 115{,}000\,t - 200$ for all diameters. (16).

Diameter of Drill in Inches. Intended.	Actual.	Pitch of Spiral. p	Tan. $\alpha = \frac{p}{\pi d}$	Cutting Angle at Periphery.	Width of Stem at Root or Backed off Portion.	Width of Stem Divided by Diam. of Drill.	Width of Chisel Point.	Width of Chisel Point Divided by Diam. of Drill.
		Inches.		Degs.				
0.75	0.749	1 in 5½	$\frac{5.5}{2.35} = 2.34$	66.9	0.117	0.156	0.085	0.114
1.0	0.999	1 in 6½	$\frac{6.5}{3.14} = 2.07$	64.25	0.166	0.166	0.096	0.096
1.5	1.501	1 in 10	$\frac{10}{4.71} = 2.12$	64.8	0.266	0.177	0.170	0.113
2.0	2.002	1 in 14	$\frac{14}{6.28} = 2.23$	65.8	0.349	0.175	0.191	0.096
2.5	2.501	1 in 18	$\frac{18}{7.85} = 2.29$	66.4	0.384	0.154	0.200	0.080
3.0	3.003	1 in 21	$\frac{21}{9.42} = 2.23$	65.8	0.399	0.133	0.224	0.075
Average.			2.23	65.8		0.160		0.096

TABLE 3. PARTICULARS OF DRILLS USED IN THE EXPERIMENTS.

For the opening-out trials in medium steel,

$P = 15{,}200\,t - 60$ opening ¾-inch hole to 1-inch diameter, (19a)
$P = 25{,}500\,t +$ opening 1-inch hole to 1½-inch diameter, (19b)
$P = 30{,}000\,t + 200$ opening ¾-inch hole to 1½-inch diameter. (19c)

In no case did the end force P reach a maximum and then diminish when the drill was fully entered as observed by Professor Breckenridge, and it can only be concluded that he was operating on cast iron having a very hard skin, or that the drill had a smaller pitch than those now in common use, i.e., a keener angle. The opening-out experiments show the fallacy of a common notion that but for the chisel point the drill would run into the work and break. This idea appears to have originated in the experiments referred to above where it was found that while an end force of 1800 pounds was necessary at the beginning of the cut to keep the drill to its work only 1000 pounds was required when drilling at the full diameter. The cutting lips, therefore, were supposed to produce a pulling-in force of 800 pounds.

At the time Dr. Nicolson expressed his dissatisfaction with the experiments on the larger drills and heavy feeds, and was of the opinion that they could not be getting their full feed. On examination it was found that there was a considerable spring in the lever C and also a slight movement in the swivel-slide of the lathe when operating with the larger drills and feeds. The former would after a time assume a constant state, yet it would tend to cross-wind the drill in the hole and stay. The latter could have been overcome by fitting dowel pins in the slides. These, together with a few minor objections and the fact that it was impossible to get a feed below $\frac{1}{1000}$ inch led to the abandonment of this arrangement in favor of that subsequently described. The experience gained with this apparatus, however, simplified matters for that which was to follow.

1	2	3	4	5	6

Torque in Foot Pounds.
Equations corresponding to

Diam. of Drill in Inches.	Full Lines on Fig. 7.	General Law $T = 785d^{1.82} + t^{0.72} - 0.0065d$ Full Lines on Fig. 9.	Nearest Linear Law not Shown on Figures.	General Linear Law $T = 10d^2 + 100t\,(14d^2 + 3)$.	Approximate General Law $T = 740d^{1.8}t^{0.7}$ Shown Dotted in Figs. 7 and 9.
¾	$T = 425t^{0.715}$	$T = 465t^{0.715}$	$T = 5 + 1100t$	$T = 5.6 + 1085t$	$T = 441t^{0.7}$
1	$T = 828t^{0.713}$	$T = 785t^{0.7135}$	$T = 10 + 1750t$	$T = 10 + 1700t$	$T = 740t^{0.7}$
1½	$T = 1700t^{0.71}$	$T = 1640t^{0.71}$	$T = 25 + 3700t$	$T = 22.5 + 3450t$	$T = 1535t^{0.7}$
2	$T = 2651t^{0.7065}$	$T = 2765t^{0.707}$	$T = 40 + 5800t$	$T = 40 + 5900t$	$T = 2575t^{0.7}$
2½	$T = 4027t^{0.7035}$	$T = 4150t^{0.704}$	$T = 60 + 8800t$	$T = 62.5 + 8760t$	$T = 3850t^{0.7}$
3	$T = 5750t^{0.70}$	$T = 5780t^{0.70}$	$T = 90 + 12900t$	$T = 90 + 12900t$	$T = 5330t^{0.7}$

Thrust in Pounds.
Equations corresponding to

Diam. of Drill in Inches.	Full Lines on Fig. 8.	General Law $P = (d - 0.4)\,325 + (24d + 65)\,1000t$ Full Lines on Fig. 10.			Approximate General Law $P = 35500d^{0.7}t^{0.75}$ Not Shown on Figures.
¾	$P = 125 + 82000t$	$P = 114 + 83000t$	——	——	$P = 29020t^{0.75}$
1	$P = 200 + 89000t$	$P = 195 + 89000t$	——	——	$P = 35500t^{0.75}$
1½	$P = 350 + 103000t$	$P = 358 + 101000t$	——	——	$P = 47140t^{0.75}$
2	$P = 500 + 110000t$	$P = 520 + 113000t$	——	——	$P = 57680t^{0.75}$
2½	$P = 600 + 126000t$	$P = 617 + 125000t$	——	——	$P = 67450t^{0.75}$
3	$P = 850 + 140000t$	$P = 845 + 137000t$	——	——	$P = 76600t^{0.75}$

TABLE 4.—SOFT CAST-IRON TRIALS.

Values Corresponding to Equations Given in the Body of the Paper and Curves Drawn on Figures.

In the opening-out trials (d) in cast iron;

$P = 11{,}330\,t + 160$ opening out ¾-inch hole to 1½-inch diameter. (17)

In the medium-steel experiments for trials (b);

$P = 26{,}500\,t + 1040$ for ¾-inch drill, (18a)
$P = 90{,}000\,t + 800$ for 1-inch drill, (18b)
$P = 155{,}000\,t + 1300$ for 1½-inch drill. (18c)

These values are shown by full lines on Fig. 3; or, generally,

$P = 160{,}000\,(d - 0.5)\,t + 1000$ for all drills. (18)

Experiments with the Second Apparatus

The second set of experiments was really a continuation of the program made out for the first, and may be briefly stated as follows:

(*e*) A series of experiments to determine the twisting moment or torque and end thrust on twist drills of varying diameter when operating on soft cast iron with different rates of feed. No lubricant used. Termed ordinary trials.

(*f*) A set of experiments similar to the above when operating on Whitworth's medium hard (fluid-pressed) steel. No lubricant used. Termed ordinary trials.

(*g*) A set of trials on soft cast iron to determine the variation of torque and thrust with different cutting speeds. No lubricant used. Termed speed trials.

(*h*) Trials to determine the variation of thrust and torque on soft cast iron and medium hard steel with different diameter of drills and rate of feeds. An initial hole equal to the width of the chisel point was drilled in the specimen operated upon. No lubricant used. Termed minus chisel-point trials.

(*i*) A set of experiments to determine the variation of thrust and torque when operating on soft, medium and hard cast iron. No lubricant used. Termed hardness trials.

(*j*) A similar set of experiments to the above when operating on Whitworth soft, medium and hard (fluid-pressed) steel. No lubricant used. Termed hardness trials.

(*k*) A set of trials similar to (*j*) but with a lubricant of oil and water. Termed lubricated trials.

(*l*) A set of trials to find the effect produced by varying the point angle when operating on soft cast iron. No lubricant used. Termed point-angle trials.

(*m*) A set similar to (*l*) when operating on soft (fluid-pressed) steel and lubricated with a mixture of water and oil. Termed point-angle trials.

Description of Second Apparatus

The experiments (*e*) to (*m*) were carried out on an old horizontal milling machine which had been reconstructed and modified at the School of Technology to allow of these several observations being made. The arrangement is shown in detail in Fig. 6, and by the half-tone, Fig. 5. The power was obtained from the motor already referred to, which drove a countershaft whereon was mounted a three-stepped cone similar to that on the machine. Two pairs of wheels were introduced between the cone and the driving spindle, but one pair could be suppressed to allow of an increased speed to the spindle. The arrangement thus permits of a total speed variation to the drill of from 5 to 150 revolutions per minute. A counter fixed to the front of the machine and actuated from the spindle indicates the revolutions. The drill is held in the rotating spindle *A* and can be advanced at varying rates, from 1/400 to 1/20 inch per revolution of the same, by suitable change wheels driven from the spindle sleeve and a square-threaded cylinder on the end of the spindle. The work is supported on an angle plate which is bolted to the faceplate on the spindle in the second headstock. This latter spindle being free to slide transmits the thrust on the drill to the diaphragm dynamometer fixed to the tail of the headstock. The twisting force is taken by an arm bolted to the faceplate and having a knife edge on its farther extremity which rests on a scale pan.

The driving wheel *B* is keyed to the cast-iron sleeve *C* which rotates within the bearings of the front headstock *D*. A long key fitted at the end of the sleeve *C* nearest to the work drives the spindle *A*, while permitting it to slide longitudinally. The employment of a sleeve as a driver in this manner reduces the twist that would otherwise come on the spindle if it were driven from the wheel *B* direct. It also divides the wear due to rotation and sliding. As the wear due to the former is greatest, adjustment for the same is provided. It is clear that if the spindle is allowed any freedom it will wabble, thereby enlarging the hole and in all likelihood breaking the drill. The feed to the drill is secured through the pinion *E*, mounted freely on the sleeve *C*, which engages the train of gears on the quadrant, bolted to the bed and the wheel *F* keyed to the screwed cylinder *G*. The wheel *F* is held in the tail cheek *H* by an annular plate, while immediately ahead of it is a nut *K* which embraces the screw *G* and is held to the cheek by pins through the hand-wheel *L*. The cylinder *G* rotates independently of the spindle and is prevented from moving longitudinally thereon by a shoulder at one end and lock nuts at the other. Friction washers are introduced between these members to take the wear. Thus on the engagement of the clutch *M* (which is keyed to *C*) with the pinion *E* a definite horizontal movement is given to the spindle per revolution of the same. The hand-wheel *L* is keyed to *K* and furnishes a quick withdrawing motion to the drill on the locking pins being withdrawn.

The torque on the drill is obtained by multiplying the load on the scale pan (after the initial load due to the weight of the arm and unbalanced weight on the faceplate have been subtracted) by the length of the arm measured from the center of the hole to the knife edge.

Balls have been fitted in pockets of the cast-iron sleeve *Q* to allow the spindle *R* to slide longitudinally with the minimum of frictional resistance. The hydraulic support to take the end thrust of the drill consists of a phosphor-bronze casing *S*, fitted with a filling plug *T* and a standard pressure gage *U*. The diaphragm *V* is of cold-drawn brass $\frac{1}{100}$ inch thick. It is held to the casing by bolts and a steel ring *W*. The thrust pad *X* is provided with a cup-shaped recess to receive the spherical end of the spindle *R*. The pad is made fast to *V* by the nut *Y* within the casing. The end thrust on the drill deflects the diaphragm at that part which is free (about $\frac{1}{8}$ inch) between *S* and *X* thereby producing a pressure in the fluid which is shown on the gage. The fluid in this case is water which has been distilled by boiling after the casing has been filled. A small filling plug is fitted in the end of the gage tube to allow any air to escape in order that the diaphragm deflection may be as small as possible. When the fluid is air-free the diaphragm will only yield by the amount necessary to supply

FIG. 5. SECOND APPARATUS BUILT FOR TWIST-DRILL EXPERIMENTS

the increased volume of the gage tube due to the added pressure. The spring of the tube is sufficient to bring the diaphragm back to its original position when the load is removed. This diaphragm dynamometer is identical with that used by Dr. Nicolson in his investigation on the cutting with a lathe tool.

The diaphragm and gage were calibrated separately and together in their places so that whatever frictional resistance to sliding was offered was taken into account. The gage dial was 10 inches in diameter and graduated in ½ pounds. If the gage were observed only to within ¼ pound this would mean 10 pounds on the drill, or a 3-per cent. error in the smallest

able. A greater irregularity is produced by drills of different degrees of sharpness. The procedure adopted throughout these trials was to use a newly-ground drill with the $\frac{1}{400}$ feed and to follow with each larger feed in order, namely, $\frac{1}{200}$, $\frac{1}{100}$, $\frac{1}{50}$, etc., without regrinding the drill. One or two sets were made with freshly ground drills for each experiment. These are slightly below the first mentioned, and show the allowance to be made on this account. The drills were never at any time blunt, as the duration of each trial was about 10 minutes after the drill had fully entered, and the speed maintained at 10 revolutions per minute for all sizes of drill. Particulars of all the drills

crease as fast as the feed for any given diameter of drill. On plotting the log. of this quantity on a base of log. of feed the values for each drill lie on a straight line. The equations to these are given in the second column of Table 4 and are represented by the strong full lines on Fig. 7. By combining these equations a general law in close agreement with all the results is obtained for all sizes of drills and feeds. Thus for the torque it is found that,

$$T = 785\, d^{\,1.82}\, f^{\,0.72 - 0.0865\, d}. \qquad (20)$$

To allow of a comparison with the formulas given in column 2 of Table 4 the equations deduced from the general

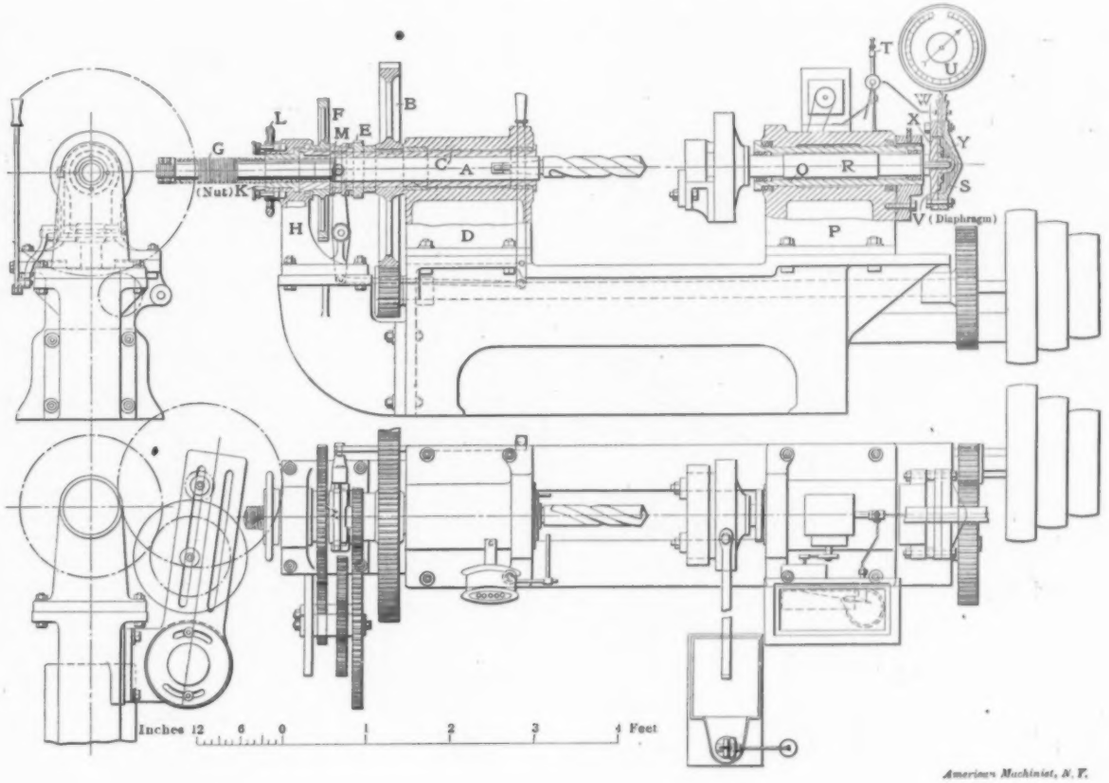


FIG. 6. SECOND APPARATUS ON WHICH EXPERIMENTS, FIGS. 7 TO 23 WERE MADE

drill and feed used, and 0.1 per cent. in the largest.

Toward the end of the trials the balls or races appear to have flattened or worn a little; as the difference between the readings obtained on the scale by pressing the arm hard on the pan and laying it gently down was about ½ pound. This would have affected the ¾-inch drill torque fully 10 per cent. for the finest feed and proportionately less for heavier feeds and larger drills. Fortunately the smaller drill trials were made first when this sticking, although looked for, was not apparent. The mean of these zero readings was taken at each trial and the vibration of the machine would overcome such sluggishness to a very great extent, so that this error in any case would be inappreci-

used in the experiments are given in Table 3. See also Fig. 4.

The results of these trials are not tabulated, but are diagrammatically recorded to a large scale. This permits of a fairer average being obtained and shows the several variations at a glance.

Soft Cast-steel Trials

The torque and thrust for trials (*e*) on soft cast iron have been plotted as ordinates on a base of feed in inches per revolution of the drill in Figs. 7 and 8. These have also been plotted on a base of diameter of drill in inches in Figs. 9 and 10. It will be observed that within the range of feeds employed in practice these values follow approximately a linear law. The torque, however, does not in-

law (20) for each size of drill are given in column 3 and represented by the full lines on Fig. 9.

As the index of f is almost constant it will be near enough for all practical purposes to take it at 0.7. The index of d may be taken at 1.8 and the coefficient modified to suit. The error in this simplified formula,

$$T = 740\, d^{\,1.8}\, f^{\,0.7}, \qquad (21)$$

is inappreciable. It is shown by the dotted lines on Figs. 7 and 9, and the value for each drill is given in column 6 of Table 4.

The linear expressions in column 4 are further approximations, and may be preferred to the exponential given above. Even these, however, when combined, do

not conform to a simple general law, the nearest approach to which is,

$$T = 10\,d^2 + (14\,d^2 + 3)\,100\,t. \quad (22)$$

The values deduced from this for each size of drill are given in column 5 of Table 4. Beyond removing the fractional indices there is little improvement. An equation of this form may be of service in making rapid comparisons and to those who are not familiar with the use of logarithms,

$$T = 14\,d^2\,(1 + 100\,t), \text{ may be near enough.} \quad (22a)$$

It will be observed that these linear values closely agree with those obtained in the first set of experiments by Dr. Nicolson.

As the drill entered the specimen the torque gradually increased and at no time exceeded the value obtained when drilling the full diameter. The drills were not allowed in any case to break through the metal.

The Effect of the Diameter on the Torque

The torque increases almost in proportion to the square of the diameter of drill for a given feed. As torque is the product of the resultant force and distance at which it acts and as these factors are each proportional to the diameter of the drill providing the stem and chisel point are some constant proportion thereof, and provided the cutting angle be constant for all diameters, the torque should increase as the square. The width of the chisel point (or thinned stem) is given in Table 3 and is about equal to $0.107\,d^{\frac{3}{4}}$ while the width of the backed-off portion is about $0.187\,d^{\frac{3}{4}}$ or approximately: Chisel point = $0.96\,d$, width of backed-off portion = $0.168\,d$. The average cutting angle for all drills in the plane of shaving (at right angles to the lip) at the periphery is

$$\frac{p}{\pi\,d\,\cos.\,30} = 68.8 \text{ degrees},$$

and the angle at the root of the stem is 90 degrees since the diameter here is very small. The angle of the cutting edge has been taken as the arithmetical mean of these two, viz.,

$$\frac{68.8 + 90 \text{ degrees}}{2} = 79.4 \text{ degrees}.$$

The mean cutting angle for the backed-off portion =

$$\frac{90 + 100 \text{ degrees}}{2} = 95 \text{ degrees}.$$

The cutting angle of the chisel point itself equal 150 degrees. Summing these mean angles, approximately,

$$\frac{79.4\,d + 7.8\,d}{d} = 87.2 \text{ degrees}. \quad (23)$$

The mean angle is, therefore, almost constant for all diameters of drills used. Proceeding in the same way it will be found that the center of pressure due to these three portions of the cutting edge occurs at a distance from the center of the drill of 0.46 time the radius. This is the point at which the resultant force may be supposed to act providing the cutting pressure is proportional to the cutting angle as assumed below. It is then clear that if the fractional exponent had been used in the above expression for the mean angle the cutting pressure would have been proportional to some value slightly less than d and the torque to some value less than d^2.

On examining the results obtained in "Experiments with a Lathe-tool Dynamometer" on cast iron the cutting pressure was found to be practically constant for all depth of cuts, but decreased slightly with the increase of traverse or feed. It was further found that the pressure was almost proportional to the cutting angle. Thus the cutting pressure in tons per square inch is:

For $\frac{1}{32}$ traverse = 0.88 × cutting angle in degrees:

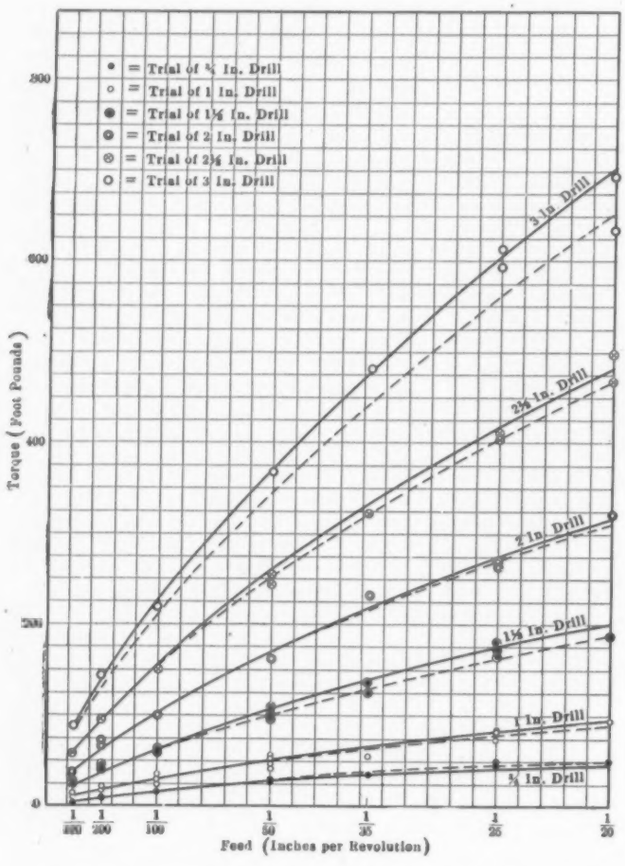
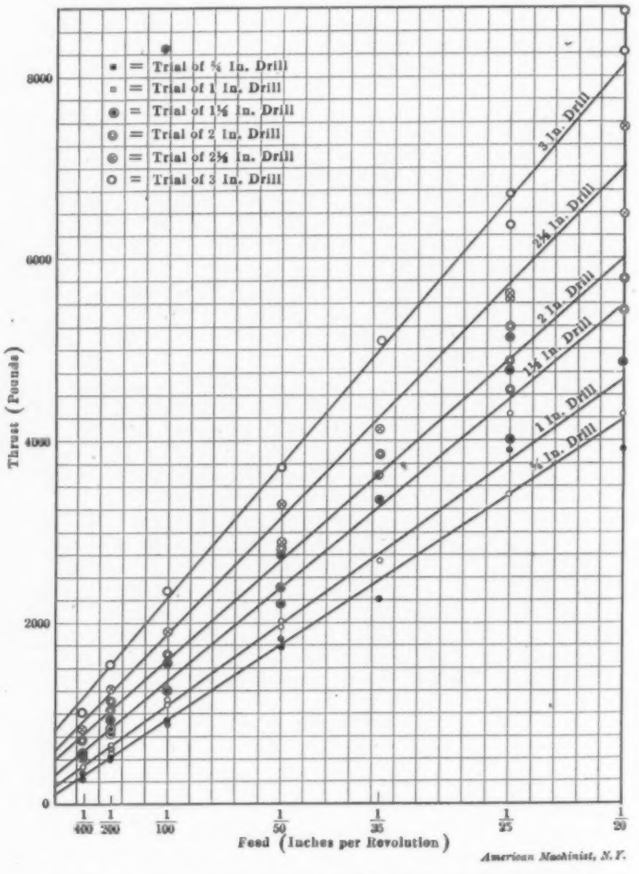

• = Trial of ¾ In. Drill
○ = Trial of 1 In. Drill
● = Trial of 1¼ In. Drill
◎ = Trial of 2 In. Drill
⊗ = Trial of 2¾ In. Drill
○ = Trial of 3 In. Drill
3 In. Drill
2¾ In. Drill
2 In. Drill
1¼ In. Drill
1 In. Drill
¾ In. Drill
Torque (Foot Pounds)
Feed (Inches per Revolution)

FIG. 7. TWIST DRILL EXPERIMENTS (ORDINARY), VARIATION OF TORQUE WITH FEED WHEN OPERATING ON SOFT CAST IRON


▪ = Trial of ¾ In. Drill
▫ = Trial of 1 In. Drill
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◉ = Trial of 2¾ In. Drill
○ = Trial of 3 In. Drill
3 In. Drill
2¾ In. Drill
2 In. Drill
1¼ In. Drill
1 In. Drill
¾ In. Drill
Thrust (Pounds)
Feed (Inches per Revolution)
American Machinist, N.Y.

FIG. 8. TWIST DRILL EXPERIMENTS (ORDINARY), VARIATION OF THRUST WITH FEED WHEN OPERATING ON SOFT CAST IRON

For ⅛ traverse = 0.70 × cutting angle in degrees :
For ¼ traverse = 0.57 × cutting angle in degrees.

The cutting angle being the true angle or that in the plane of the shaving.

A simple law combining the cutting angle and traverse is:

$$f = \frac{0.35}{t^{0.33}} \times \text{cutting angle.} \quad (24)$$

For a cutting angle of 87.2 degrees the pressure is,

$$f = \frac{0.35 \times 87.2}{t^{0.33}} = \frac{30.5}{t^{0.33}} \left.\right\} (24a)$$

tons per square inch.

The traverse, however, in a two-lipped twist drill is halved, *i. e.*, each lip takes half the feed so that t, in the case of the lathe tool is equal $2t$ in the drill. Modifying the above equation for twist drills,

$$f = \frac{30.5}{\left(\frac{t_1}{2}\right)^{0.33}} = \frac{38.5}{t^{0.33}} \left.\right\} (25)$$

for a mean angle of 87.2 deg.

$$f = \frac{0.44}{t^{0.33}} \times \text{cutting angle.} \quad (25a)$$

Assuming the cutting pressure to be proportional to the angle, the torque required for the complete drill is,

$$T = 17.55\ r^2\ t^{0.7} \text{ inch-tons;}$$
$$= 3275\ r^2\ t^{0.7} \text{ foot-pounds;}$$
$$= 819\ d^2\ t^{0.7} \text{ foot-pounds.} \quad (26)$$

This is to be compared with the expressions

$$785\ d^{1.82}\ t^{0.72 - 0.0065d}, \quad (20)$$

and

$$740\ d^{1.8}\ t^{0.7}, \quad (21)$$

given above.

The difference is due to value assumed for the cutting pressure.

Taking the resultant force acting at $0.46r$ as found above then the cutting pressure is,

$$f = \frac{79{,}500}{d^{0.2}\ t^{0.3}} \text{ pounds per sq. in.} \left.\right\} (27)$$
$$= \frac{35.4}{d^{0.2}\ t^{0.3}} \text{ tons per sq. in.}$$

The stress so deduced and that obtained for the lathe tool given above show a very satisfactory agreement. What difference there is, is no doubt due to the different qualities of metal operated upon.

The cutting pressures on a 1-inch twist drill with varying feed when operating as soft cast iron as deduced from the above formula are,

$t = \frac{1}{400}$, $f = \frac{35.4}{0.0025^{0.3}} = \frac{35.4}{0.1658} =$ 214 tons.

$t = \frac{1}{200}$, $f = \frac{35.4}{0.005^{0.3}} = \frac{35.4}{0.204} =$ 173.5 tons.

$t = \frac{1}{100}$, $f = \frac{35.4}{0.01^{0.3}} = \frac{35.4}{0.2512} =$ 141 tons.

$t = \frac{1}{50}$, $f = \frac{35.4}{0.02^{0.3}} = \frac{35.4}{0.309} =$ 114.5 tons.

$t = \frac{1}{25}$, $f = \frac{35.4}{0.04^{0.3}} = \frac{35.4}{0.3806} =$ 93 tons.

It is clear from the equation (27) that this stress decreases with an increased diameter of drill.

Results Regarding End Thrust, Soft Cast Iron

Notwithstanding the care taken throughout these trials the results of the end thrust when drilling cast iron show no greater consistency than those obtained in the first experiments. It was expected at

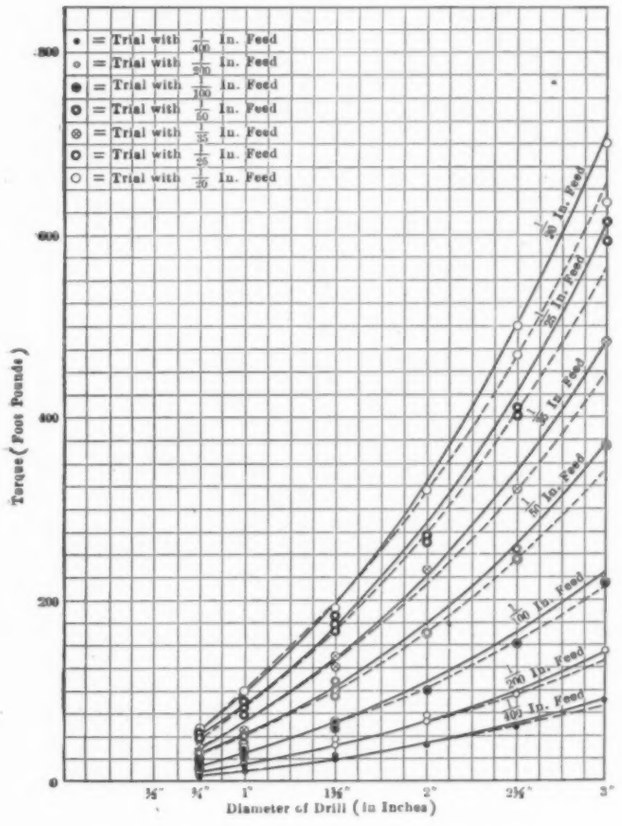


FIG. 9. TWIST DRILL EXPERIMENTS (ORDINARY), VARIATIONS OF TORQUE WITH DIAMETER WHEN OPERATING ON SOFT CAST IRON

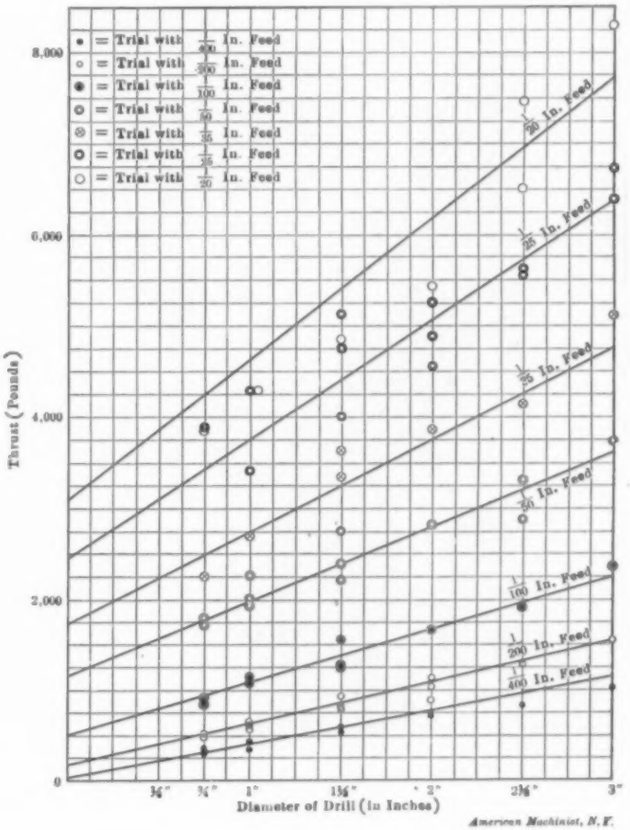


FIG. 10. TWIST DRILL EXPERIMENTS (ORDINARY), VARIATION OF THRUST WITH DIAMETER WHEN OPERATING ON SOFT CAST IRON

the outset that these values would be absolutely regular, as the only chance of error would be in observing the gage reading. The diaphragm and gage were calibrated at frequent intervals and the same constant was obtained each time. The metal appeared to be very uniform, having neither blow-holes nor hard patches. The results are given on Fig. 8 and Fig. 10; the former showing thrust on a base of feed, and the latter thrust on a base of diameter of drill.

The strong full lines drawn through the mean of the spots on Figs. 8 and 10 indicate that these results follow a straight-line law more nearly than anything else. The equations to the lines on the figures are respectively given in columns 2 and 3 of Table 4, and these agree with the general expression,

$$P = 52{,}900\, t^{0.93 - 0.087\, d}. \quad (29)$$

This equation can be made to generally agree with:

$$P = 35{,}500\, d^{0.7}\, t^{0.75}. \quad (30)$$

As this form of equation is likely to prove most serviceable to the practitioner the values deduced from (30) for each diameter of drill are given in column 6 of Table 4 in order that an estimate of its degree of accuracy may be made.

(To Be Continued)

Striking Power of a Steam Hammer

By W. T. Sears*

The cut of a hammer, Fig. 1, shows the 800-pound Niles-Bement-Pond Company's hammer of which a detailed description is doubtless unnecessary. The mechanism for operating the valve, which is one of the principal features of this type of hammer and which must be correctly designed in every respect to insure an active and satisfactorily working hammer, is one that gives a variable cut-off to the valve and is easily controlled by the operator. The force of the blow is thus regulated at will and also the speed.

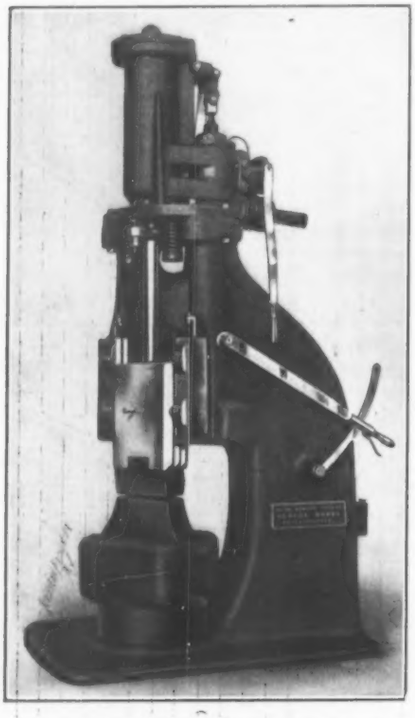


FIG. 1. 800-POUND NILES-BEMENT-POND STEAM HAMMER

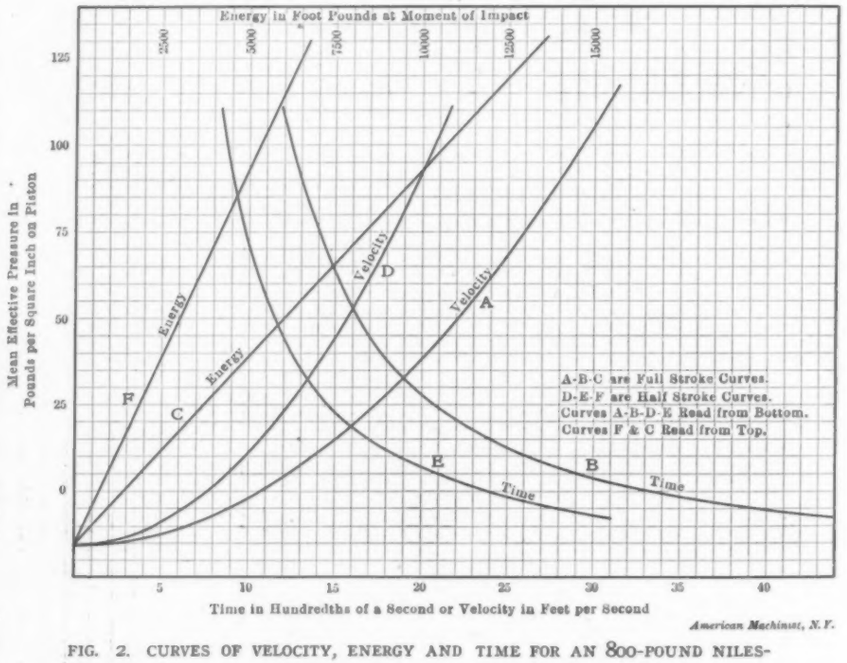


FIG. 2. CURVES OF VELOCITY, ENERGY AND TIME FOR AN 800-POUND NILES-BEMENT-POND STEAM HAMMER

The chart, Fig. 2, shows graphically the velocity of the moving parts and the concentrated energy stored in these parts at the moment of anvil impact, also the time for a down stroke. These three values are calculated and plotted for a full stroke of the hammer and for a half stroke.

Referring to the chart, A is the full-stroke velocity curve, B the full-stroke time curve and C the full-stroke energy curve; D is the half-stroke velocity curve, E the half-stroke time curve and F is the half-stroke energy curve. For instance, if it is desired to find the velocity at the instant before impact with the anvil, and the energy stored in the moving parts at that time, of such a hammer with a mean effective pressure on the piston of 25 pounds at full stroke, we find first the mean effective pressure given on the left of 25 pounds and following horizontally to the right to intersections with curves A and C and then vertically below for A and above for C, we find the velocity to be 174 feet per second and the energy to be 3750 foot-pounds. In the same way the time for a full stroke under these conditions would be 0.207 second.

By the use of lead cylinders to obtain the energy in the moving parts, the process can be reversed and with a given stroke we can very closely approximate the mean effective pressure on the piston at the time of test. Certain friction losses occur which can be roughly approximated, however, and the actual results are quite accurate.

The curves are carried below the zero point for the reason that the mean effective pressure often falls below zero, or, in other words, when striking very light blows the steam is not entirely exhausted from the bottom of the piston, or live steam may be admitted below the piston to check the speed. The mean effective pressure for the entire stroke will thus be at times a negative quantity, but of course never greater than sufficient to not quite balance the weight of the moving parts; otherwise, of course, no stroke would take place.

$$P = (d - 0.4)\, 325 + (24d + 65)\, 1000\, t, \quad (28)$$

$$P = 240\, d + (24\, d + 65)\, 1000\, t. \quad (28a)$$

This latter law is simple enough but is rather clumsy to be of much use to the designer. For some purposes it may be good enough to take,

$$P = 200\, d + 10{,}000\, t, \quad (28b)$$

which is roughly correct for ordinary feeds. To simplify equation (28) the log. of the thrust was plotted as an ordinate on a base of log. of feed and the line drawn through the mean passed through a common point.

This made the coefficient of t a constant for all diameter of drills. The slope of the lines for each was different, however, so that the index of t was a function of the diameter of drill. The expression obtained by this means is,

*Engineering Bureau, Niles-Bement-Pond Company.

Practical Letters from Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

Cam Milling Machine

Figs. 1 to 6 herewith show a machine and attachments for milling cams for four-cylinder automobile engines, a cam shaft being shown in Fig. 7. These cam shafts are manufactured in quantities from a good brand of steel, and call for very accurate workmanship. The ordinary method of milling cams to shape on a universal milling machine is very slow and costly, and besides, the fact that the indexing of the cams to exactly 90 degrees apart depends entirely upon the operator at once introduces the danger of incorrect indexing, and should a slip occur, it cannot afterward be rectified. With the machine here shown, it is quite impossible to scrap the work through carelessness in dividing, as when the work is fixed in the machine the dividing and locating of the four cams in correct relative position to one another is done positively, and practically no skill on the part of the operator is called for; furthermore, as the cams are milled to a former, they are finished accurately to shape, whereas with a universal milling machine, from half an hour upward is required to finish each separate cam with a file, to bring it to its correct shape and dimensions.

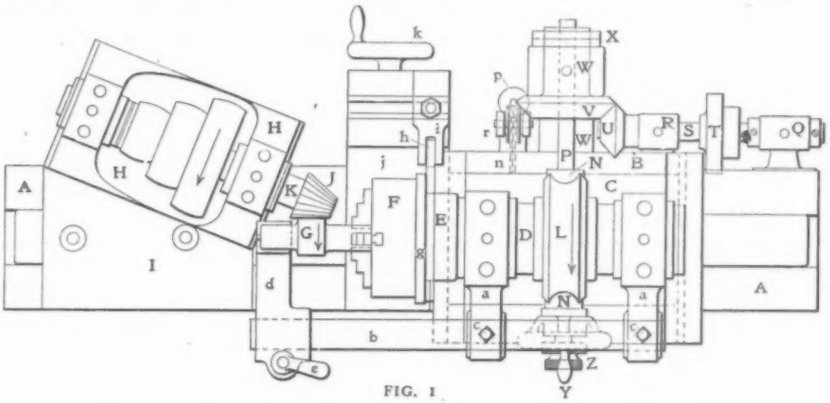


FIG. 1

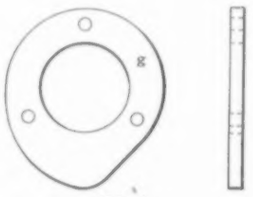


FIG. 4

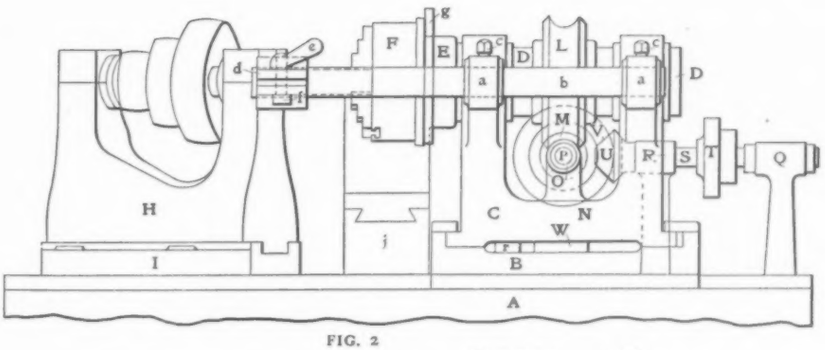


FIG. 2

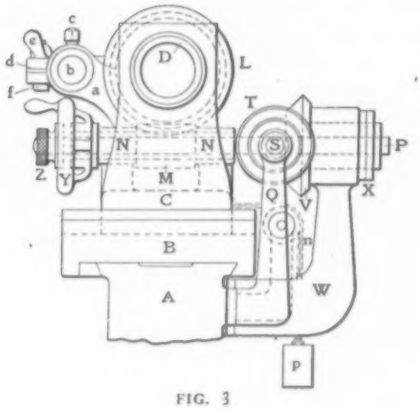


FIG. 3

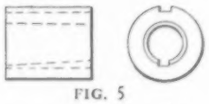


FIG. 5

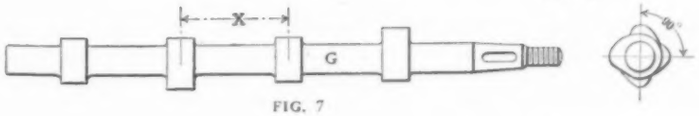


FIG. 7

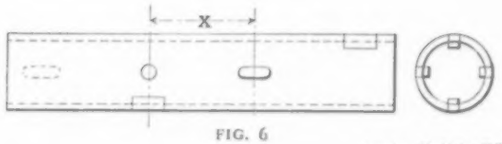


FIG. 6

American Machinist, N.Y.

CAM-MILLING MACHINE

Referring to Figs. 1 and 2, *A* is a gray-iron bed, cast from the pattern of an engine-lathe bed; *B* is a slide, into which the movable headstock *C* fits, as shown; *D* is the hollow main spindle for carrying the work, onto which is fitted the adapter plate *E*, which carries the 8-inch three-jaw universal-geared scroll chuck *F*, in the usual way, but with the exception that the mounting screws have fillister heads, and the flange on *E* is recessed to allow them to stand flush with the back of it, so as not to be in the way of the former plates when mounted. In the plan, Fig. 1, *G* is a cam being milled; *H* is the headstock which carries the cutter spindle *K*, and is offset, as shown, by the angular adapter plate *I*, which is also planed to fit the slot in the bed, and secured by two bolts; *J* is the angular milling cutter, which is driven by a key in the end of the spindle *K*.

L is a worm wheel, also shown in Fig. 3, which is an end elevation with the headstock *H* and adapter plate *I* removed. *M* is a steel worm, the end of which can be seen in Fig. 2; it is keyed onto a hollow steel sleeve *C*. This tube is supported

in the two brackets *N* which are cast solid with *C*. *P* is a splined shaft passing through *O* and also extending backward through the bevel wheel *V*; *Q* is a bracket secured to a planed seat on the back of the bed, and *R* is identical with it; these two brackets support the feed shaft *S* on which the cone pulley *T* is keyed. This shaft is prevented from moving endways by the two collars located at either side of *Q*. *U* is a small bevel wheel which drives the large bevel *V*, which has a long hub on the back and is carried by the bracket *W*. Two locknuts are located on the threaded end of the bevel sleeve, as shown, to keep it in position when working. *Y* is a hand wheel keyed on the steel sleeve *O*, which in turn is keyed to the worm *M*; the front of the hub on *Y* has a dog clutch, which engages with a similar clutch milled on the knob *Z*, which is keyed directly on the splined shaft *P*. Thus when the cone pulley *T* revolves and drives the sleeved bevel *V* through the medium of the small bevel *U*, the shaft *P* is kept constantly rotating, being driven by a key let in the bore of *V*, which engages with a spline on the end of *P*. When the clutches on the faces of *Y* and *Z* are engaged, the worm *M* also revolves, and drives the worm wheel *L*, which operates the work spindle *D*. Should it be necessary to stop the latter, however, for any cause, and also to revolve the work by hand very quickly, or slowly, as the case may be, all that is necessary is to pull the nurled knob *Z* until the clutches disengage, when the worm and wheel instantly stop, as the driving member is then free. A stop collar can be fitted on the rear end of the shaft *P* to prevent it from being drawn out any farther than necessary.

The two overhanging arms or brackets *a a*, cast on *C*, are bored out to carry the shaft *b*, which is locked securely in position by the two set screws *c c*. At *d* is shown an adjustable swinging arm, with a V cut in the end for supporting the work and giving it additional rigidity under heavy cuts. The locking handle *e* is for securing shaft *b*, by operating on the bolt *f*. A gray-iron former plate is located at *g*. This is about ½ inch thick, and is machined on the edge to the exact shape it is required to mill the work to. This former is about five or six times as large as the work intended to be operated on, and is shown in detail in Fig. 4. It is bored out to fit the boss of the adapter plate *E*, and secured by three set screws passing through the three holes shown in Fig. 4. In Fig. 1 *h* is a hardened-steel guide roller which runs on the periphery of former *g*; it is carried in the forked steel holder *i*, which is secured to the top slide of the rest *j*. The hand wheel *k* is for operating the roller *h* by the usual cross feed screw. A chain *n* passing over a grooved pulley carried on the bracket *r* supports the weight *p* and keeps the former plate *g* up against the steel roller *h*, so that the exact shape of former *g* is reproduced to smaller scale on the work *G*.

The dividing of the four cams is accomplished in the following manner: The gray-iron bush, Fig. 5, is slipped onto the tapered end of the cam shaft, Fig. 7, where the timing wheel is keyed, and securely fastened by the nut on the outer end; this bush has a keyway cut in the outside, as shown, and it is turned on the top to a nice sliding fit in the bored and turned steel locating tube, shown in Fig. 6. This tube has four feathers or short keys let in as shown, exactly at 90 degrees apart, and longitudinally the same distance apart as the center of the cams to be cut as denoted at *X*, in Figs. 6 and 7. The tube is inserted in the hollow spindle of the machine, in which it should be a nice sliding fit, and is secured by two set screws passing through the spindle *D* and entering holes in the tube. One of these holes is shown in Fig. 6, the other hole being at the opposite side. The chuck jaws are opened sufficiently to allow the collars on the cam shaft to pass through, until the keyway in the bush, Fig. 5, comes up against the first key in the tube, Fig. 6; it is then turned round until it passes onto the key, when it is securely gripped in the chuck and the first cam cut, the cutter and cam shaft rotating in the direction indicated by arrows in Fig. 1. If a fair amount of stock is to be removed it is necessary to mill twice around the cam to produce a good smooth finish. In the roughing cut about 1¼ inches circumferential feed per minute can be taken, while for finishing a feed of 2 inches and even more, per minute, can be employed.

After the first cam has been milled, the chuck jaws are slackened and the cam shaft pulled through, until the bush on the end comes in contact with the second key in the tube, Fig. 6; then the shaft is turned around slowly until the keyway slips over the key; the work is now set, the chuck tightened and the next cam cut as before; and so on until the job is completed.

In the spacing and dividing of the keyways in the locating tube, great care is required, as upon the accuracy of this depends the character of the work turned out by the machine; by our former method of procedure when we milled these cams on a universal milling machine, using highly paid labor, it always took from 8 to 10 hours to complete a shaft for a four-cylinder engine, and after that it took a skilled fitter quite 3½ hours to file a shaft up accurately to gage. With this machine a boy can complete a shaft in from 1 to 1¼ hours and produce a first-class job requiring no filing. Of course for cams of different throw, different formers are required, also if the distance *X*, Fig. 7, varies, different locating tubes like Fig. 6 are required.

Detroit, Mich. L. HODGES.

Should a Machinist Leave His Machine Running While away from It?

The above question has been answered for me on several occasions very emphatically, indeed so emphatically that I found myself looking for another job. I am possessed of a restless temperament which would never allow me to stop a large boring mill or planer while I went to sharpen a fresh tool, and if the emery wheel was some distance away and there were one or two ahead of me it often happened that 10 minutes would elapse before I could be back at the machine I was running. Once or twice something happened; a pulley which was left on a boring mill with the rim being turned was found looking more like the spider, with here and there a foot or so of iron sticking out from the end of an arm to show what had been. On this particular occasion I went to the foreman and told him that he was going to fire me, and when he inquired the reason I took him to the mill, and had the pleasure of hearing his opinion of me, and then "Billy, I ought to kick you out, but we are shy of boring-mill hands and so you will have to stay." I felt rather cheap, but made up for it by working that mill for all it was worth for the next two months.

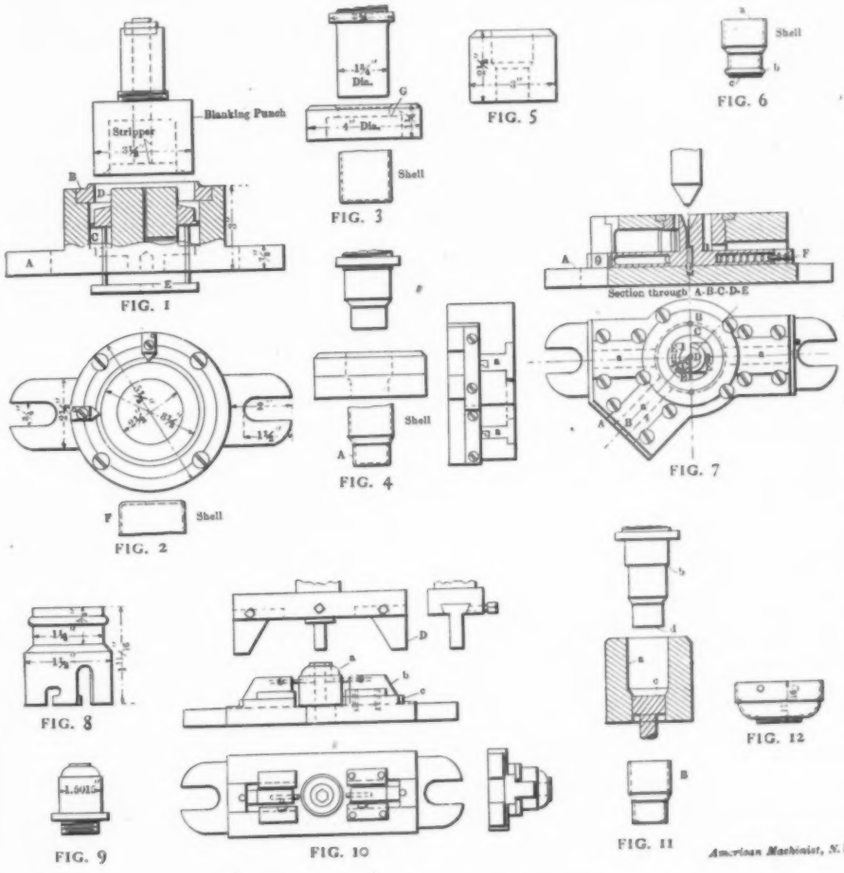
How many of the readers of the AMERICAN MACHINIST have had to stop their machines to get a drink? Naturally everyone who ever worked in a machine shop on a machine will either answer "I," or else acknowledge that they committed the dreadful act of leaving the machine to look after the cut or cuts itself. And why not? Why should an expensive lathe or other tool not be expected to perform its work for a few minutes without the ever watchful eye of Jack or Fred? In these days of automatics it is time for foremen and managers to see that, say a $100 casting spoiled per year through leaving the machine to take care of itself (when necessary to leave) is more than paid for by the innumerable times that it is working away faithfully, while its master is properly engaged at a distance. Of course, not even the one casting need be spoiled, but there are certain things such as blow holes, which even a Sherlock Holmes could not be expected to have advance information about, and which should not be set against either Jack's or the machine's account.

Having in the space of a few years encountered this question so frequently myself, I here lay the matter before others who, no doubt, can throw light on it from various standpoints, if they will spare time from their investigations of high-speed steel long enough to observe that where 10 minutes per hour is gained by the use of a certain brand, an extra 10 could more easily be gained by keeping the machine running the full 60 minutes.

Ottawa, Can. W. L. McL.

Tools for Drawing a Lamp Socket and Base

The tools shown are for making a brass lamp socket and a cap for it called the base. Fig. 1 is the first operation; it is constructed as follows: *A* is a cast-iron shoe into which is fastened securely the blanking ring *B* and the forming punch *D*. The ring *C* is the stripper (shown part way down on *D* so that it could be seen plainly), held up level with the top of the blanking ring *B* and a sliding fit on *D*. The plate *E* is the knock-out with four upright pins in it, upon which the stripper *C* rests.



TOOLS FOR DRAWING A LAMP SOCKET AND BASE

The blanking punch, shown above, has also a stripper (shown by dotted lines), with a collar at the top of the punch to keep it from dropping out. When the blanking punch comes down it cuts off the metal by shearing through the ring *B* and pushes down the stripper *C*, which keeps the metal from wrinkling. The metal forms around the punch *D*. The punch *D* pushes the stripper up in the blanking punch on the return stroke of the press. The plate *E* has a heavy rubber spring underneath it which pushes up the ring *C* which in turn pushes the shell off *D* and up inside the blanking punch. The stripper in the blanking punch is now at the top of the punch with the shell underneath it. Just as the press reaches the end of the return stroke a kicker on the press strikes the end where the collar is, and pushes it down and the shell out.

The ring *B*, forming punch *D*, stripper *C*, and blanking punch are all made of tool steel hardened and ground to size. Fig. 2 is a plan of the die just described with some dimensions given to show the exact size of it. *F* is a view of the drawn shell. Fig. 3 is the punch and die for the next operation, which draws the shell down to 1¾ inches diameter. This die is held in a cast-iron shoe by a cap, which tightens down on the edge which is beveled off at a 45-degree angle.

The shank of the punch is made the same as the blanking punch of Fig. 1. This punch pushes the shell right through the die and on the return stroke the shell being formed around the punch catches on the sharp edge *G* of the die (shown by dotted lines) and pulls it off the punch, and it drops through the hole in the bolster plate on the press.

The next operation is another reducing punch and die the same as Fig. 3 only smaller in diameter and is not shown. Fig. 4 is a reducing punch and die for the small end of the shell. This die is made in halves. The top half is bored to just take the shell without drawing it and is left soft.

The bottom half is made as shown by the dotted lines, and reduces the shell like that shown at *A*. In this operation the shell is pushed back out of the die by a knock-out fastened into the center of the shoe into which the die fits, and is stripped off the punch by a ring fastened on the top of the cap that holds the die down.

Fig. 5 is the finish draw made of one piece, hardened, ground and lapped exactly to size. The punch is made the same as the punch Fig. 4, the only difference being that it is the exact size, being about 1/16 inch smaller at both diameters, which I find leaves the shell nice and smooth. The shell is now trimmed off level on the large end, to a gage to keep it the exact length from the beveled edges. It is next put on a set of rolls on a beading machine and beaded, as shown at *b*, Fig. 6. The bottom of the shell is next trimmed off to gage from *A*, and is then taken and put through the operation of piercing the slots in the die, Fig. 7, which punches the slots all at once.

In Fig. 7 the cast-iron shoe *A* is shaped and bored out to suit the parts *A A A B C*. The parts *A* are of soft tool steel and are held in place by the screws shown in the plan. The shape of the parts *A* can be seen in the end elevation. They are made so that the parts *E*, which hold the punches, are a nice working fit. They also have grooves cut through them to allow the punchings to push out.

The ring *C* is the die which is held in position by the outer ring *B* which holds it down, while the dowel pins keep it from turning around. The lower part of the die *C* is held in the shoe, as shown in the cross-section, and it is impossible for it to get out of place.

It can be seen by the cross-section where the slides *E E E* all are forced up against the center pin by the coil spring shown, each slide having the same, though only one spring is shown. The springs pushing up against the plate *F* push the slides *E* up against the pin *G*. The punches are fastened into the slides *E* and are held firmly by fitting into a slot in the bottom and through the upright part, being riveted on the side nearest the center pin. I have never known one of them to come loose yet, and they have produced thousands. The top of the slides are bored to a 60-degree angle, and the end of the punch is turned the same angle.

The shell is placed over the punches *E E E* and inside of the die *C*. The punch then passes down through the shell, pushes the slides *E* apart and forces the punches through the shell and into *C*. Upon the punch releasing the springs push the slides *E* back against the center pin, the punchings pass out through *A*, and the shell is lifted out. The shell now looks like Fig. 8. The base, Fig. 12, as it is called, is drawn in one operation, being blanked and drawn in a single-action press. It is made in a die the same as shown in Fig. 1, with just this difference:

A forming punch, shown at Fig. 9, is made, and a blanking punch is made to suit Fig. 9 to form the metal into the required shape.

The base is then trimmed to a gage and put through the punch and die, Fig. 10. It is placed over part *A*, and the punch coming down pierces the hexagon hole in the top and continues down until the taper punches *D* strike slides *b*. In this case a coil spring (not shown) is in the inside and pushes against *A*. This pushes the slides out against the stop pins *C*. The punchings all push in to the center, and drop through. The taper punches *D* are adjustable to suit the job.

The punch and die shown at Fig. 11 is to draw the fiber lining. This is made from fiber tubing, cut to required lengths, and which comes the right diameter to fit into the large diameter of the shell, but requires drawing down to suit the small end.

The die at *A* is bored to suit the tubing, which is set in and rests on the beveled edge. The punch passes down through the fiber until the shoulder *b* strikes the top edge and pushes it down and around the bevel and onto the stripper *c* for about ⅛ inch all around. By this time the end *d* of the punch catches it and pushes it against *e*, which is actuated by a strong spring. The combined forces draw the fiber into the shape shown at *B*.

It is then taken and trimmed off on each end to gage, and is then put through a die similar to Fig. 7, the only difference being that instead of small slots being made the same as in the shell, they are made square, and about 1/32 inch allowed on each slot for clearance.

Belleville, Ont. D. B.

Subpress and Dies

As modern methods of manufacture have been evolved, a change has been made in the construction of dies for accurate work. Through lack of alinement between the old-style punch and die, constant repairs were necessary to keep the tool in working condition, and uniform blanks were found to be impossible. To avoid this, the barrel subpress, having a steel plunger for the punch sliding in a babbitted bearing, was devised. This makes a self-contained unit and is well adapted for the most delicate work, but it cannot be used for large blanks and for some work its cost is prohibitive.

The next step is shown in the illustration in Fig. 1. This subpress consists of two castings, one a flat plate *A* bored to receive the two hardened and ground pins *B* and *C*, and provided with clamping lugs for fastening to the bolster plate. The subpress top *D* has two bosses to fit the pins and long enough to afford a good bearing. The holes in top and base are drilled from the solid metal and bored together in a jig; they are finished by hand reaming and in the top are bell-mouthed at *E* so that oil will stay on the pins when the subpress is in use. The top member is cast to the dotted line *F* and the T-slot milled out to receive the machine-steel plunger *G*. For clamping to the bolster plate a cast clamp, as shown at *H* will be most efficient.

The pins are of a low-carbon steel and after hardening are ground to fit each individual subpress. To insure the most accurate results, after one hole is drilled and reamed in each pair of castings, the finished pin is pressed into the base, the top pushed on and the other hole then bored and reamed, using the first pin as a dowel. This design of press allows of an unlimited range of work and can be used for blanking, compound, piercing and forming dies.

In this subpress the pins are not made the same size, as an inexperienced press hand may remove the top from a symmetrical die and replace it in the wrong position. The castings are machined on the planer in gangs of eight to twelve, to reduce the manufacturing cost. In designing dies an attempt should be made to keep the screw holes and dowels in a uniform position, so that if a die is made obsolete because of changes in the piece, the subpress may be fitted to a new job. The dimensions *I* and *J* should be made to fit the size of dies most commonly used.

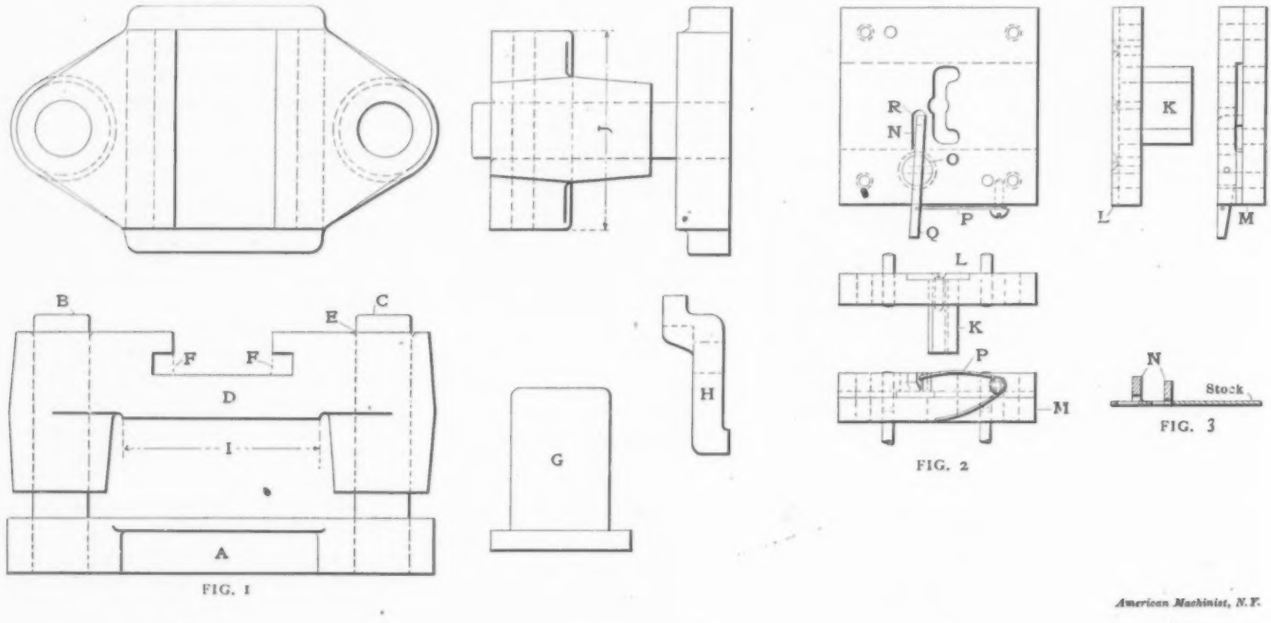


FIG. 1

FIG. 2

FIG. 3

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SUBPRESS AND DIES

In Fig. 2 is shown a blanking die used in this subpress. The punch *K* is made straight and driven into the punch pad, which is worked out to receive it. The pad has a slot shaped out for a hardened and ground backing plate *L*, which is fastened to the punch and pad with three flat-head machine screws. Two dowels and four 5/16-inch fillister-head screws provide for fastening to the subpress.

The die *M* is fastened in a similar manner and is located by two dowels, which are made tight in the stripper plate and the subpress, to allow of readily grinding the die face. The stop *N*, which has a double movement, swinging horizontally on the stud bearing *O* and moving up and down through the slot, is normally held on the die face, as shown by means of the simple wire spring *P*. When an adjustable stud in the subpress top descends

with the punch and strikes the trigger at *Q*, the stop *N* is raised and turns to rest upon the corner of the stock, as shown in Fig. 3. As the trigger is released the stop enters the blank opening and the pressure of the stock forces it again to place, as at *R*, Fig. 2. In this design, the punch pad, die and stripper plate may be bored out on the bench lathe with the same face-plate setting, thereby making proper alinement a certainty.

Chicago, Ill. L. P. SITTIG.

A Belt Drive Change

After installing the new planer and testing it, the drive, which was by cross belt, see Fig. 1, could not deliver enough power to work the machine to its full capacity. The lack of power was due to the belt slipping, and when heavy work was put through the machine would come to a standstill.

Conditions in the room around the machine made it imperative to maintain the short distance, 10 ft., between centers, and the small diameter of countershaft pulley, to keep up to the required speed.

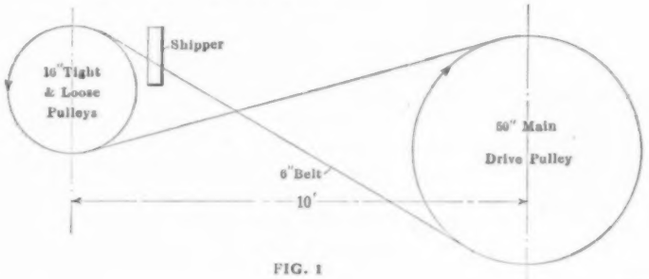

FIG. 1

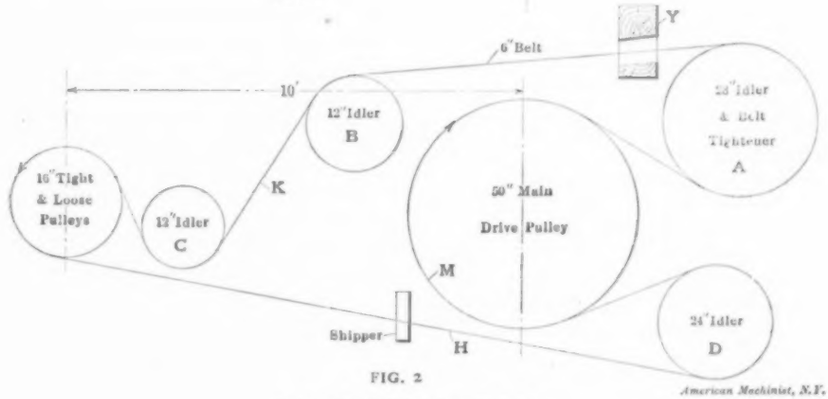

FIG. 2

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THE OLD AND THE NEW DRIVE

After a careful study of the conditions the scheme shown in Fig. 2 was resorted to with very gratifying results. It will be seen by referring to Figs. 1 and 2 that from a cross belt, the drive was changed to an open belt, whereby we were able to put in a 12-inch idler pulley *C*, Fig. 2, so as to obtain a greater belt contact on the counter pulley *X*.

To get the results shown the belt was led from the main drive pulley *M* to idlers *A B C*, the counter pulley *X*, back to the idler *D* and then to the main drive pulley *M* again. The timber *Y* had to be cut to let the belt through. In the drive shown we were able to take advantage of the idler *A* and convert it into a belt tightener. A strong frame was made with a groove on the inside, wherein there is a sliding frame supporting the bearings for the idler *A*. The whole is worked by means of a hand wheel, screw and bevel gears.

A noteworthy feature of this drive is the method of shipping the belt. Fig. 1 shows the well known method of shipping the belt, the shipper working against the loose side of the belt when shipping.

In Fig. 2 this condition is reversed and works on the right side. The shipper was first put in front of the idler *C* at *K* on the loose strand of the belt, but it worked very hard and the belt had a great tendency to work its way back to the loose pulley when subjected to a heavy load. On putting a stick up against the tight strand of the belt at *H*, it was noticed that the belt went right over to where it belonged with very little pressure and remained there so long as the stick was up against it. The shipper is now located at *H*.

The length of belt on the old drive was 27 feet. The new drive requires 54 feet of belt. It has been running two months and is giving us no trouble whatever.

Worcester, Mass. ANTHONY.

A Handy Drill Socket for Piece Workers

A simple scheme, familiar to many machinists, is the following cheap and easy method of equipping the ordinary drill socket so that a drill may be quickly removed from the socket, and replaced by another without stopping the drill press.

Fig. 1 shows clearly the construction. Only two new parts are required. The ring *A* is made a sliding fit on the body of the drill socket. The upper edge of *A* is rounded, as shown at *a*. A screw *B* shown in place in Fig. 1, and alone in Fig. 2, passes through one side of the ring *A* through the tang hole of the drill socket, and screws into the opposite side of the ring.

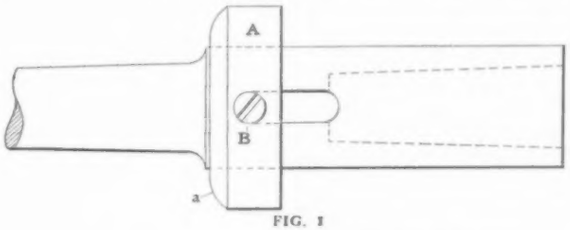


FIG. 1

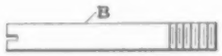


FIG. 2

American Machinist, N.Y.

A HANDY DRILL SOCKET

With a drill in place and the socket running in a drill press it is only necessary to give a sharp rap with a hammer on the rounded edge of the ring *A* to cause the drill to drop. Another drill can be thrust in place with the hand at once.

This saves the time of stopping and starting the press, which will be appreciated by all doing piece work.

Rochester, N. Y. F. C. MITCHELL.

Transferring Holes

Here is a kink that a friend of mine used. It was new to me and may be new to some others.

In building experimental machinery, much of which requires accurate fitting and drilling, he had the usual trouble in locating holes to be laid off from a piece already drilled in which the holes were very deep. The scriber being useless, or at best rather inaccurate by reason of its bearing on the outer edge of the hole, after setting the blank piece he takes a bar of round, cold-rolled stock the size of the hole and with a chisel or center punch raises a small bur on the end of the bar, anywhere between the center and the circumference. By shoving the bar into the hole until it touches the chalked blank and then rotating it once or twice, he obtains an accurate circle from which to strike off the center.

Rochester, N. Y. RALPH W. DAVIS.

Discussion of the Previous Question

Letters from Our Readers Showing How Many Men of Many Minds Look upon Various Subjects Opened up in Previous Numbers

WE PAY FOR THESE ALSO

Device to be Used in Lettering Drawings

The device of T. J. S. Kishpaugh, page 431, used while lettering tracings, will do the work intended, but when making out a bill of material or something of that nature one must wait for the ink to dry before lowering the device.

I have a slender skewer, held in the left hand, the point holding down the tracing cloth just above where the pen travels. In that way better time can be made and there is no danger of blotting the fresh ink and causing unkind remarks.

Cleveland, Ohio. D. T. FLETCHER.

Tools for a Ball Thrust Cap

In the article, "Tools for a Ball Thrust Cap," on pages 508 and 509, I was much interested in the tools for the first operation, boring and facing, inasmuch as some similar work had come up in our own factory. I wondered whether, in bringing the lathe cross-feed against the stop there would not be a variation in its position, thus causing a change in location of the cutting edges. This, of course, would mean a difference in the diameter of the hole bored.

It may be possible that the accuracy required is not great, thus allowing a thousandth or two difference in diameter. But in the work we had to do, it was necessary to have the holes as exact as possible considering the cost. The only change I have to suggest in the tool holder shown in Fig. 2, page 509, to obtain these more accurate results is to place the cutter in a horizontal position, and to allow it to be perfectly free, so that it can "float" forward and backward. No screw is used to hold the cutter in place, and it finds its own center upon entering the hole. The great advantage of this type is that no stop is required to give accuracy to results, only to give the approximate location of the holder. After the cutters were ground to size, we stoned, with a fine oil stone, the front and back corners, causing the slightest roundness at these places. The result of this stoning was a hole in cast iron resembling very much a lapped hole in a hardened-steel bushing, so smooth and true was it. For accuracy we found that in lots of 100 pieces, the hole did not vary one-quarter of a thousandth of an inch in diameter.

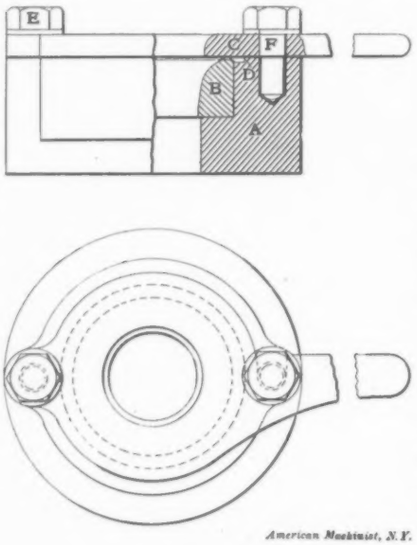
I have given the above, thinking that Franz Valtier, the author of the article referred to, may find something of value to him in my suggestion.

C. A. HOEFER.

Freeport, Ill.

A Hand Applied Blank Holder for Drawing Sheet Metal

On page 858, Volume 31, Part 2, there appears an article, the writer of which gives data by which may be determined the smallest diameter shell which may be drawn from a given blank. This information will be useful to those toolmakers who have much to do with combination tools, or who have double-acting presses to draw their shells with. To those less fortunate, and those who find



HAND APPLIED BLANK HOLDER

themselves in small shops with few tools, the sketches herewith may be commended.

To get the smallest shell out of a given blank, a blank holder of some description must be used, and if the plant has not a double-acting press then a hand-applied blank holder must be devised, such as shown in the line cut. *A* is the bolster of gray iron, *B* the drawing die and *C* the hand-applied pressure plate. *D* is the set edge for the blank.

In operation the blank is placed in the set edge, and the blank holder, which is pivoted on the bolt *E*, is swung round from left to right and under the head of the bolt *F*; this is the position as shown. When in this position the punch passes through the hole in the blank holder and draws the blank through the die. It is obvious that if the space between the upper surface of the die and the lower surface of the blank holder be only equal to the thickness of the blank, the wrinkling of the edges of the blank will be effectually prevented.

Without a blank holder, a shell may be drawn only to a depth at most equaling two-thirds its diameter, and in many cases only to a depth equal to one-half its diameter.

With a blank holder as shown, shells may be drawn to a depth equal to three-fourths to seven-eighths its diameter.

With a blank holder similar to the one described all sorts of blanks may be handled round, rectangular and irregular.

WULFRUNA.

Birmingham, England.

A Draftsman's Precision Needle Point

Any improvement in drawing instruments is something to be appreciated, more especially where fine, accurate work is required. While not wishing to depreciate the ingenuity shown in the scheme adopted by a number of draftsmen in using a small sewing needle in conjunction with a split bushing for compasses, as described at page 277, I might say that this idea is by no means new. A patent was taken out some years ago for a similar but more perfect precision needle point, and as I have used this type of point in my drawing instruments for about 10 years I can testify to its reliability. The miniature bushing is slightly taper externally and drilled to receive an ordinary small sewing needle; two slits extend about three-fourths of its length, the lower end being solid and drilled or pierced to suit the needle point. By this means the point of the needle is held perfectly rigid; the bushing itself can be clamped in any desired position to suit the length of the pen or pencil point by the screw in the compass leg in the usual way.

I may add that a source of trouble which frequently causes annoyance to a draftsman is the inaccurate manner of securing the lead in the pencil point. Even in some of the best made instruments the clamping screw is placed near the top end of socket, some distance from the point of the lead; in time the split socket becomes permanently forced open at the lower end, thereby causing the lead to

float, under which condition it is impossible to describe a true circle. It would be more mechanical if the clamping screw were midway, or nearer the low end of the socket in the pencil leg. If enough force is used to spring a needle point, as described in the previous article, the paper will certainly tear; but the objection to the needle point or the lead floating, will be quite obvious.

Glasgow, Scotland. O. SAVILLION.

Best Results in Hardening Steel

I am tempted to answer Mr. Osborne's article on the best results in hardening steel, as I am able to answer all the questions and arguments that are presented, to my own satisfaction. The mere hardening of a piece of steel is, to me, a simple definite operation like eating when I am hungry. I wish to dodge one thing, however, and that is any classification in the scientific class; I lack such precise instruments as pyrometers and microscopes, and have to get results with a common hand forge.

Hardening a piece of steel is simple, but hardening the same piece of steel after it is worked into a long reamer, or into a ring of irregular cross section, or into an odd shape with peculiar-shaped holes, where there are thick and thin walls, then to have that piece of steel stand up to its work, and come out of the bath as hard as possible with the least warp and the least strain, is quite another matter. It is a mysterious and complicated ceremony, and often is the final ceremony undergone by that piece of steel.

Few books have been written on the hardening of steel, but many on hardening articles made of steel. Different baths, coatings, packing in various materials, and heating in various ways are all the result of one or more of the requirements stated. Any piece of tool steel that can be hardened by any scheme, or combination of schemes, can be hardened by the common method of heating above the critical point and quenching in water, but it may only be scrap when it comes from the water. Cracks, warps and strains manifest themselves as a result of the various expansions in heating, and contractions in cooling, and sometimes some very obscure and paradoxical causes bring vivid results.

I shall use the technical terms used by E. F. Lake in the large and valuable article on "Steel," published about a year ago, in No. 13, Part 1, of Vol. 31. I also wish to quote from this article to illuminate the dark corners and bear out my reasoning. The terms mentioned, I line up as follows, in the order of their existence in steel and my interpretation of their meanings:

Ferrite, pure iron.

Cementite, carbide of iron, carbon and iron in the ratio of 1 to 3.

Pearlite, fused iron and carbide of iron, or fused ferrite and cementite ratio about 32 to 5.

Sorbite, fused pearlite and cementite, formed by an ascending heat that changes the pearlite to

Martensite, or hardenite, the hardest combination of the elements of carbon steel.

Austenite, present in overheated steel, softer than martensite.

Troostite, caused by quenching on a descending heat, is present in all tempered steel and is a reversion of martensite toward pearlite, very similar to sorbite.

In hardening a piece of steel, its appearance is the guide, giving the proper heat or critical point itself, even for various carbon contents in various steels. This is the explanation that is wanted by Mr. Osborne: At a certain heat or point, heat is absorbed without a corresponding increase in the temperature of the steel, and at this stage the steel remains a dark red. As the critical point is past, however, this dark red changes to a lighter color, and it generally changes at the corners and thin places first, so that the two colors are usually visible at the same time. One color being stationary for quite awhile and the hotter color coming in, shows that the steel is again rising in temperature, or apparently reheating. Thus the recalescent or reheating point was probably discovered on a rising heat and not on a falling heat, as assumed.

Careful and constant attention must be given to notice this phenomena. The eyes cannot be dazzled by sunlight, or a hot fire, or by flares of gas from green coal that light up and change the color values, also, certain known conditions must exist. The fire must be deep enough not to burn out or require fresh fuel; the blast must be constant and not too strong so that we know that the fire is a constant factor and not variable. Heating a ring of from 3 to 6 inches in diameter makes this appearance very apparent. Rings should be heated by leaving a portion exposed above the fire for tong hold, and continually turning them from the moment they go in until they come out, for the sake of even heating. This explains how a hardener can know the critical point by the appearance of a piece of steel without knowing the carbon content.

My impressions of what happens to a piece of steel in hardening are pretty well outlined in my interpretation of the terms used by Mr. Lake. As to particular cases this question comes first: Where above the critical point is the best point for quenching to get the best results? At the critical point, or as near to it as possible, so long as above it and on an ascending scale.

There is a lag to magnetism, light, heat, etc. For instance, the longest day of the year is June 21, but the hottest ones are in August, as the earth lags, or absorbs heat, without a great rise in temperature all that time. While steel is absorbing heat at the critical point without getting any hotter this heat is changing the pearlite to martensite, and if the heating is slow and even there will be no increase in temperature until all the pearlite is transformed to martensite. When this occurs there is no need of heating the metal any higher, but to make sure the change has taken place it is necessary to heat steel slightly above the recalescence point. This will bring all parts of the piece to the same temperature. Further heating begins the formation of austenite, which is softer than martensite and tends to coarser crystalization or overheating. Steel does not get harder the higher it is heated. Mr. Lake gives on page 494, Volume 31, Part 1, the extreme limit above the critical point at 40 degrees, the same figure holding for annealing. I quote: "The higher the temperature above the critical point the lower will be the tensile strength and the less will be the hardness of the steel; the elongation will also show a decrease and this will mean that the steel becomes more brittle with each increase in the temperature."

As to the relation between toughness and hardness (not brittleness) both the troostite and sorbite are lower values of the martensite. Sorbite, formed on an ascending heat, I have found to run in patches and spots. Perhaps these come from finger or oil marks or spots where tongs or coal have been in contact, or from slightly uneven heating. I prefer to use the troostite state, for instance instead of toughening steel I prefer to harden thoroughly and draw accordingly —and I have hammers made of 1.25 per cent. carbon steel that stand the racket and do not chip.

I consider troostite as being in the nature of a binding material; that is, a lower formation of martensite that is integral with or welded to it and forming a homogeneous mass. The molecules that were under stress in the martensite formation having been able to adjust themselves, and through the tempering heat, to flow slightly and fill such interstices as may exist between the atoms of martensite.

Sorbite or toughened steel, to my mind, is in a more or less strained condition, having had no intermolecular adjustment and the elements having been halted in their growth, there naturally will be different growths and different values for them.

I do not consider that any quenching bath can give a harder steel than can be produced by water or brine, provided that both quench from the same temperature. I have cracked enough pieces in water, a little too cold, and certainly do not want anything colder. Good systematic agitation of the metal in the bath will make steel so hard that it is of no use unless

let down. A very little heating makes a great difference. Mr. Lake says. . . . "The more rapid the cooling from 1650 (low carbon steel) to 200 degrees Fahrenheit, the more effective will be the hardening process. These are the temperatures at which the transformation which corresponds with the hardening process begins and ends." Also "The specific heat of mercury is much less than that of water and the cooling of quenched steel is three times as rapid in water as in mercury. The hardening effect is, therefore, much lower than that of water but surface cracks and fissures are not nearly so liable to occur."

Red visible in daylight is about 900 degrees Fahrenheit, and red visible in the dark about 750 degrees Fahrenheit and no steel that I ever used would harden at these temperatures. Razor-temper steel (1⅓ points carbon) calls for about 1400 degrees Fahrenheit which is to me a dark cherry red while set temper (⅞ point carbon) wants about 1600 degrees Fahrenheit. I often quench tool steel at a "red in the dark" to anneal it in a hurry and sometimes I can't wait until it is cooler than a "red in daylight." So I think someone was stringing Mr. Osborne.

In closing I wish to again emphasize the distinction between hardening a "piece" of steel and hardening a complicated delicate tool and still have a useful article that is reliable; and there is room for more literature on the subject, if it touches basic principles. I also wish to advise a careful study of Mr. Lake's article which is quoted above.

Belvidere, Ill. JOHN SIRIUS.

Cutting and Threading a Long 8-inch Pipe

M. S. and H. C. G., on page 583, seem to lose sight of the fact that the necessity for accurate work was what induced me to use the device described on page 187. We were constantly obliged to cut over and supply new flanges where the method of "feeding in" had been practiced. Our pipe is double thick and two of the joints that I fitted had already been cut over once, but by making new flanges with longer hubs, and consequently longer fits and the angles to perfectly correspond I was enabled to get a good tight job and make the pipe come the exact length, as originally, which was necessary, as it had to fill the place where it was taken out.

I can readily see that with a taper attachment to "feed the tool in" evenly, M. S., or H. C. G.'s method would give good results and would have been adopted, had we a lathe of that kind available for that purpose.

Concord, N. H. W. H. KING.

Hobbing Machines

Is the generating machine for hobbing gears a failure? According to P. A. Thompson's article on page 126 it appears to be and I think it is for producing silent gearing running at high speeds, although he states that Mr. Humpage has patented a hob that generates a true involute, a statement that I do not think either Mr. Thompson or Mr. Humpage can prove. I have seen and used a quantity of cutters of all sorts in generating machines, all from the best makers, and they all fall short of a perfect involute.

There are only two distinct types of generating machines, the shaper and the hobbing machines.

Now take the case of the Fellows gear shaper, these machines are very fine pieces of machinery and reflect great credit both to designer and manufacturer.

Take any two gears that have been cut on this type of machine and roll them together in a center-measuring machine, one will find a very uneven action; indeed this uneven action is due entirely to the incorrect shape of the teeth. On examination of the teeth one will find that they have only contact on the pitch circle and a little way above and below. This failure of bearing surface causes these gears to run with a minute hammering action, which accounts for the very high shriek that one gets from these gears when run at 1500 to 2000 revolutions per minute.

The Fellows people have endeavored to eliminate this by using a form of stub teeth and with, I believe, a very fair amount of success, which success I hope will always be with them.

The hob-milling type of gear-generating machine made by Humpage, Thompson & Hardy is, I think, one of the best if not the best of its class, although it falls short in all round usefulness when compared with such machines as the Burnatzky as this machine cuts spirals automatically, a point that is essential to the production of first-class, efficient and cheap gearing. The gears cut on these machines have a rough tooth, which can be partly got over if the hob is subjected to two streams of lubricant at about 10 and 5 pounds pressure, the 10 pounds pressure to be applied parallel to the axis of the hob and the 5 pounds steam at right angles. This way of lubricating the hob requires the work to be entirely boxed in. The flats that Mr. Thompson speaks of are due I think to three causes: 1st, chips getting between the cutting edges of the hob and the work faces (pressure-fed lubricant will clear all chips out if applied as described above); 2d, the hob in all these machines has a lot too much movement before it takes up its cut (this could be very easily eliminated by designing a drive that has no play and that can be readily adjusted when wear takes place); 3d, the greatest criminal of them all, it is the spring in the hob stock due to the torsion of the shaft. I can hear someone say, make the shaft strong enough to resist this. Yes, that is the obvious thing to do but that involves a redesign of the machine because if one set of parts is stiffened all others must be stiffened to correspond.

Manchester, Eng. H. H. WILSON.

Helps in Cutting Threads

The help referred to by C. C. Walton on page 232 is undoubtedly useful especially when used with the finer-pitched leading screws, and on reading it, my mind was carried back to my own youthful days at the lathe, my trouble with the "odd" thread and the way out of it.

Just in front of me worked an old turner and one day I saw him cutting an odd thread without chalking his wheels or stopping his lathe. I asked him how he knew where to drop his nut in. He smiled and said, "guess at it." You just try—I did and have done it ever since.

It is a fine idea especially on short outside work with a leading screw of say, ½-inch pitch, cutting 9 threads 2 inches long. The tool is always withdrawn at the same place and takes the same time. The same can be said of the nut and the saddle. Now assuming that we have taken a cut up, we withdraw the tool, release the nut and return the saddle. While this is being done, the thread we must not *drop in* will be just about passing. (You can feel it by a slight pressure on the lever engaging the nut) and you know that the next thread is the right one. While this is coming along you set the next cut and away you go. I have cut many hundreds of odd threads like this and rarely have had a cross thread, then only through carelessness. To use this method a man has to become as it were a part of his machine. His movements must bear an exact relation to the speed of his lathe. In the instance given we would be able to take one cut for every 3 inches travel of the lead screw, while using chalk marks or any similar method the cut would more likely be one in every 4 inches, the reason being that with the one the eyes have only to be used for setting the cut while with the other method the eyes have to be used for setting the cut then for watching the chalkmarks. On the face of it there seems a good deal of risk but I would give the same advice that was given me. "Try it." Another useful help for screw cutting, especially on brass work is to find the actual depth of thread, then work for depth entirely from the indexed collar on the screw.

P. E. JAMES.

London.

Safety Devices in Machine Shops

I take it to be common ground that the avoidance of accidents, or at least their reduction is desirable from a business point of view as well as a humanitarian one. In order, however, to attain the object it is necessary to look at various factors. It seems part of human nature that he who suffers pain or loss will generally try to put the blame for it upon someone else. The mere existence of compensation laws and safety devices will not make an appreciable difference, unless these things are understood and treated in a suitable spirit by all concerned. I am inclined to think that it is the lack of proper understanding, and due consideration of these matters which caused the somewhat disappointing results mentioned by John E. Sweet, printed on page 228.

A few illustrations will, perhaps, show my meaning. I have seen overseers and foremen make fun of, or sarcastic remarks to, men for taking precautions against accidents from belts, gearing, emery wheels, etc. A man who contemptibly disregards all danger, puts a 5-inch belt on a 3-foot pulley by hand while it is making between 150 and 200 revolutions per minute is praised for his pluck; truing up big emery wheels without guards or goggles, and so forth, in almost an endless chain, gradually brings promotion. Treatment like this starts series rivalry between nearly everyone, for few prefer to retain their health and be considered cowards.

When accidents happen the manager wonders how they occur in spite of his strict instructions; and the insurance companies will bring forward these instructions of the manager and the safety devices which were disregarded by this careless man.

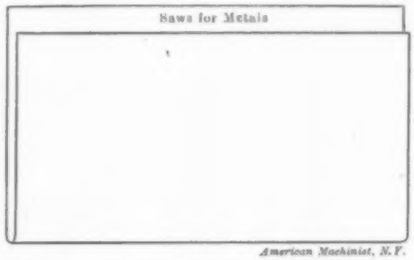
It is a fact that not every time a belt is put on a moving pulley a man gets killed, which encourages such actions. Do not promote the man who, with a certain amount of luck, defies danger, but warn him or discharge him for disobeying factory regulations. With regard to foremen, they must be capable of distinguishing between courage, caution and foolhardiness. It will be of little use to blame the man who gets hurt, if the one who does not get hurt through the same disobedience is tolerated, or even promoted.

Safety devices must be made practical. Goggles, for instance, having a separate small piece of glass, perhaps an inch or so in front of the eye and some black-painted iron netting all around, interfere with the line of sight, and have the effect of almost twisting the eyes out of their sockets; this feeling is by no means better than having some grit temporarily in the eye. An iron poker for a press may be quite effective, but it has a way of falling on the floor and getting kicked all over the shop. Surely a neat stripper actuated by the press would not be beyond the ability of a toolmaker, and would be effective and rid of the danger of being discarded. Safety guards which kept hanging on the wall while the dangerous machines are being used without them are testimony to the discipline of a shop; before employers ask for penal clauses to further punish the already punished ones, it would be advisable to ascertain whether factory regulations and safety guards are not negatived by their representative who has a great admiration for the pluck of other people.

London, England. W. Le Dierp.

The Card Index System of Filing Notes and Clippings

I read with considerable interest the article on page 399, entitled "The Card Index System of Filing Notes and Clippings," and I wish to say that I consider the card system to be by long odds the best for this purpose, both on account of the convenience with which the clippings can be filed and its great expansibility, it being equally complete with one clipping or ten thousand. I also have gone through the various preliminary stages of the game, having started some years ago with



American Machinist, N.Y.

FOLDER FOR BUNCHING CLIPPINGS TOGETHER

a scrap book in which I pasted a few clippings which I wished to preserve. I soon found, however, that I was unable to keep clippings pertaining to the same subject together and that it took too much time to prepare and paste them in. These troubles and what Mr. Halsey calls the "chronic case of the article which is printed on both sides of the sheet" brought me to the conclusion that what was necessary was some method of caring for the loose clippings so that they could be easily filed and certainly found. I tried the portfolio scrap book and found it to be unsatisfactory for the reason that in any system of attached indexed receptacles some get filled while others are nearly empty, as Mr. Halsey found. The flat letter file and the envelops are not convenient to refer to and after a trial of both they were discarded.

I now use a vertical filing cabinet, invoice size, which takes a sheet 6½x9½ inches without folding. The drawer is equipped with a set of alphabetical guide cards but the clippings are filed between the cards in folders as shown in the accompanying sketch, which keeps the small clippings from getting down into the bottom of the box and enables one to keep together all clippings pertaining to any one subject. By this method the labor of filing is reduced to a minimum and, as the folders are comparatively inexpensive, one can assign a separate folder to every different subject with the added advantage that when any subject is to be referred to, that folder can be lifted out with all of the clipping pertaining to that subject unmixed with any others. As the article referred to states, if any other plan offers so many advantages I am not aware of it but would like to have it brought to my attention.

Gardner, Mass. Lewis C. Travers.

Graduating Tailstocks

I was much taken with the article on page 488 by F. E. Fick, Govans, Md., upon "Another Method of Graduating Tailstocks." I heartily agree with his method of finding the required center by means of a hardened ground arbor, or by turning the end of a shaft. I furnish herewith a more accurate and quicker method than the chisel marks or lines upon the adjusting screws which are only rough adjustments. To mark the tailstock, drill and ream with a No. 0 taper reamer in the back or front where the upper and lower portions come together, then insert a taper pin with a nurled head, or drill through the taper pin at the large end and drive a small piece of wire forming a handle to remove it by. I think Mr. Fick will agree with me upon this method. I have used it for 20 years very successfully. I also use the same method upon the cross slide and compound slide to set work for different operations.

Kane, Penn. H. L. Bean.

Fixture for Milling Quick Pitch Multiple Lead Screw

I was interested in the description of the fixture by Mr. Kirkhouse at page 358. I would suggest that it might be well to put a worm wheel on the end of the former screw in place of the hand wheel. The worm box could be carried from the screw as well, so that the worm and worm wheel would move along with the screw as the worm wheel revolves. Disks for indexing can be fixed to the worm wheel. Here I would suggest the use of a disk with a large number of holes so that by using a number that is a good common multiple, several screws can be cut without having to alter the disk for every different number of threads. With a handle on the end of the stud carrying the worm, I think the operation would become very much less laborious for the operator. This little extra work on the fixture would greatly increase the number of jobs that could be done on it.

Padiham, England. J. Rollinson.

Some Railroad Tools and Devices

By Ethan Viall

As a general rule, the most interesting places in a railroad shop, for the average mechanic, are the machine shop and tool-room. However, an inspection of almost any of the other departments of a good sized plant will usually reveal enough to make the time well spent.

Many devices or ways of doing work, while old to railroad men in general are new to mechanics in other lines. It is also true that most of the railroad shops have developed some special tools or devices suited to their special needs that are unknown in other railroad shops, but of which they would like to learn.

In the Big 4 shop at Matoon, Ill., I found the master mechanic to be W. K. High, and the general foreman, W. H. Quandt. The tool-room foreman, O. T. Harroun, showed me an adjustable die head or chaser holder, which has an adjustment of a quarter of an inch. This is shown in Fig. 1, and is so simple that no explanation is needed.

Fig. 2 shows a chuck for holding drills made from flat bar steel. These drills are made of a suitable length and pointed on both ends. A hollow cone-shaped stop on the inside of the chuck body, and which is held in place by the pin *A*, centers the end of the drill. The body of the chuck is made of heavy tubing, the shank and slotted end being screwed in. The body of a chuck showing the slotted end is shown at *B*, the jaws at *C*, and the adjusting cap at *D*. A number of the double-end drills are shown at the right.

Fig. 3 is a reamer holder or "socket wrench" made on the same plan as the die head shown in Fig. 1.

It will be noted that the jaws are inserted off center in order to have them in contact with the driving sides of the reamer shank.

Fig. 4 is a flue-sheet cutter, the shank of which is made of carbon steel with

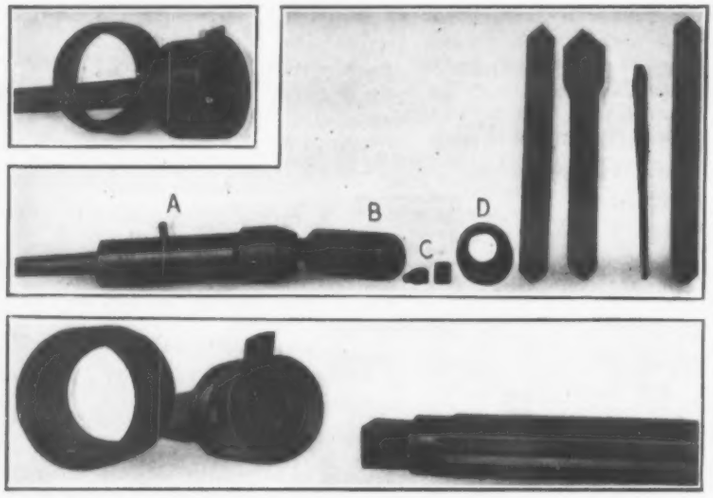


FIG. 1. DIE HEAD WITH CHASERS
FIG. 2. CHUCK FOR HOLDING FLAT DRILLS
FIG. 3. ADJUSTABLE REAMER WRENCH FOR LATHE

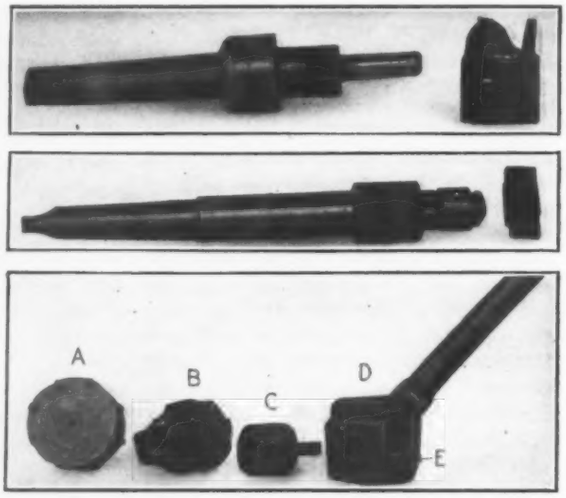


FIG. 4. FLUE-SHEET CUTTER
FIG. 5. FACING TOOL
FIG. 6. TAPS AND STAY-BOLT WRENCH

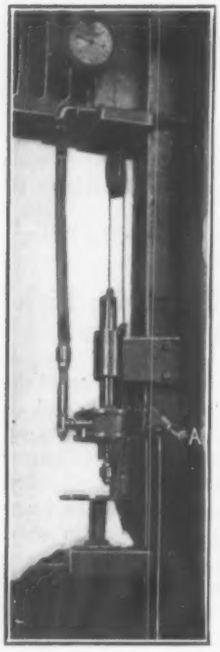


FIG. 7. AIR-DRIVEN SENSITIVE DRILL

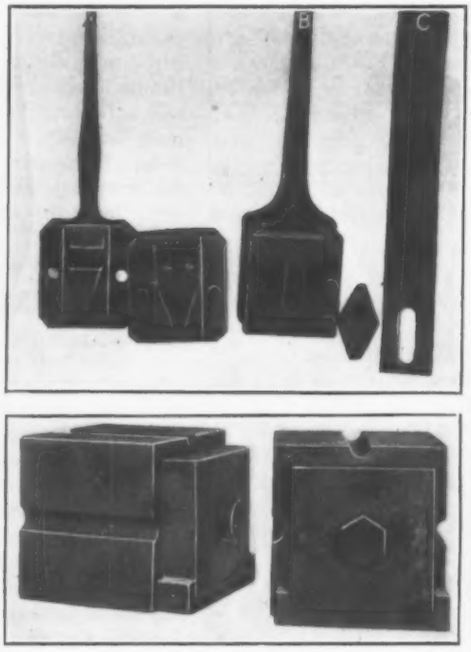
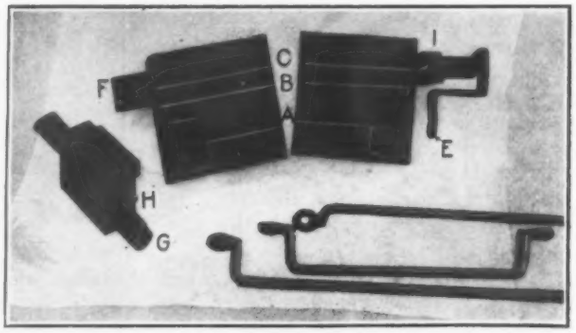


FIG. 8. STEAM HAMMER DIES
FIG. 9. RENEWABLE BLOCK IN DIES



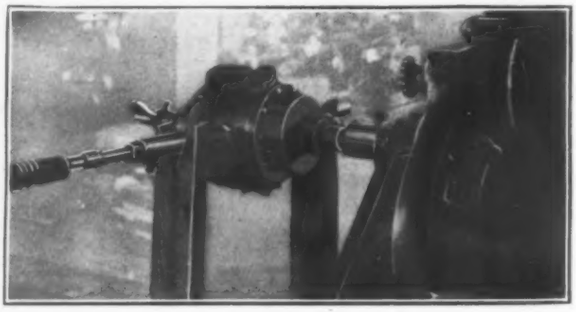


FIG. 10. FORGING DIES FOR HANDHOLDS
FIG. 11. DRIVING LATHE WITH AIR DRILL

hardened pilot. The cutter is made of Blue-chip high-speed steel and is held in place on the shank by means of the set screw which fits into the L-shaped slot in the shank. This method of fastening holds the cutter securely, yet affords instant removal for sharpening without taking the shank from the machine. This tool has a record of fifty-four holes an hour, and a two-hour run without being touched up.

A good way to make a facing tool is shown in Fig. 8. Cutters of any length or width may be used in this holder. The shank is made of machine steel, with a case-hardened locking collar and hardened toolsteel pilot bushing, which is held in place by a washer and screw.

An Air-driven Drill Press

A small sensitive air drill is shown in Fig. 7. This was made from such parts as could be found in the shop. The weight of the motor and chuck is counterbalanced, as shown, and is easily moved up and down by means of the hand lever *A*. The table or platen, may also be raised or lowered by screwing it right or left.

In the blacksmith shop, in charge of J. E. Binns, I found a set of forming and piercing dies used under the steam hammer for shaping the ends of car springs as in Fig. 8. The forming dies are shown inserted from either side so as to tighten or loosen a stud as desired.

Running the Shop by Air Motors

Over on the other side of town, at the Illinois Central shops, I found that a few days before my visit the big flywheel on their engine had burst and put their power plant out of commission. Fortunately neither the boiler nor the air compressor was damaged and so they were running a good many of their machines with air motors, which the master mechanic, F. W. Taylor had had coupled on to help out until the engine could be repaired. Lathes, drill presses, grinders and several other machines were doing very well, run in this way.

Fig. 11 shows how a big air drill was coupled onto a lathe and Fig. 12 shows a smaller one attached to the spindle of a drill press. It is the ability to utilize what one has, that marks the real mechanic.

A device used to turn the tumbling shaft ends, which is shown in Fig. 13. This consists of a body carrying a center, fastened securely to the lathe spindle, over which is placed a sleeve carrying a cutting tool *B*. This sleeve is free to move back and forth on the body but is driven

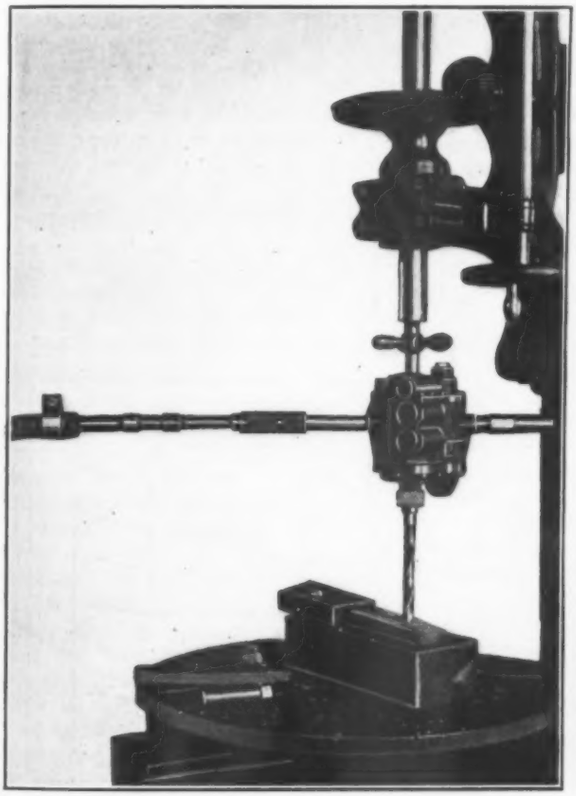
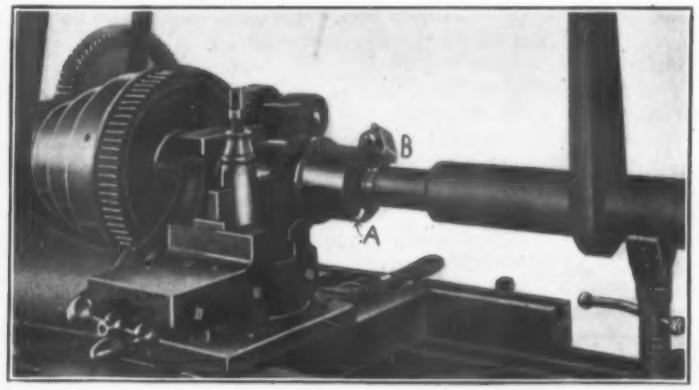


FIG. 12. USING AIR DRILL IN DRILL PRESS WHEN ENGINE IS BROKEN DOWN



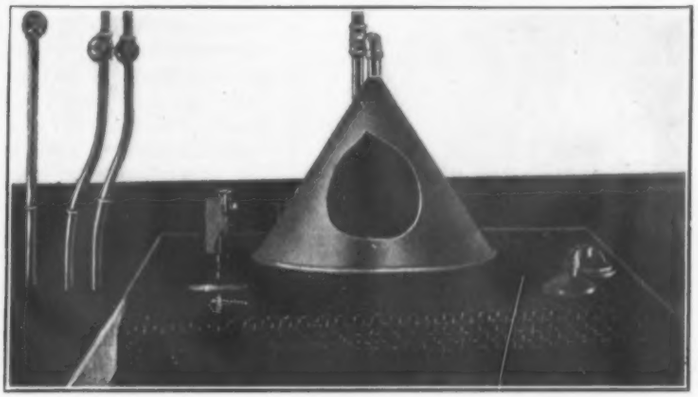


FIG. 13. TURNING THE ROCK OR TUMBLING SHAFT
FIG. 14. CLEANING OIL AND DIRT FROM AIR VALVES

In Fig. 6, *A* and *B* are taps with inserted cutting blades, the body being made of machine steel. These blades are made a few thousandths larger than the slots and are pressed in. In case a blade becomes damaged on the cutting end, it is pressed forward and the end reground, making it as good as new.

C is a stay-bolt wrench, the square shank of which fits into the socket of an air machine. The threads on the inside are cut taper like a pipe thread. After the stay bolt is in place and the wrench backed up these taper threads easily release.

The device shown at *D* is a wrench used on steam chest studs. A taper key *E*, with alligator teeth on one edge allows of a non-slipping grip. This key may be at *A*, the piercing die and punch at *B*, and the finished end of a spring at *C*.

In the bolt-heading machines, the part of the dies to wear out first, is the part that forms up the head of the bolt, so these dies are made as shown in Fig. 9, and when the part that forms the bolt head wears out or chips off, the part may be turned around or replaced without the necessity of making an entire new die block.

Fig. 10 shows a set of punches and dies which are used in an Ajax forging machine for making the hand holds shown in the lower part of the picture. These hand holds are forged, punched and bent in one heat.

The straight rod is first placed in groove *A*, against the stop *E*, and the head is forged by the punch *G*, at one stroke. The forged end is then placed in recess *B*, and the hole punched by punch *H*. It is then placed in groove *C*, and bent by the projecting piece *I*, which also flattens the end against block *F*. The whole operation is performed in three strokes of the machine and is done as fast as the forging machine can make the strokes.

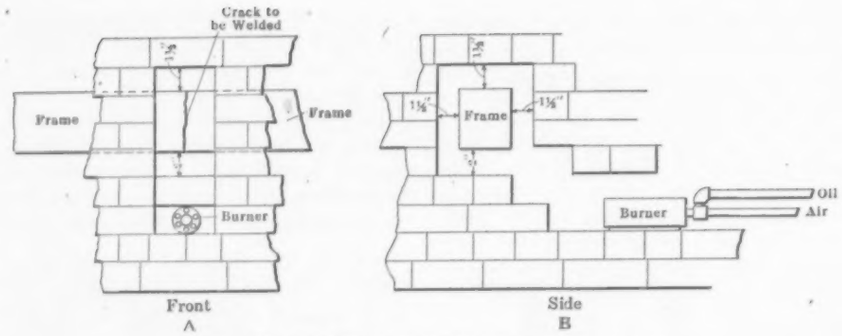


FIG. 18. METHOD OF WELDING LOCOMOTIVE FRAMES

with it, as the spindle turns, by the key *A*.

The sleeve may be run out while revolving by means of the fork held in the lathe toolpost as shown, and in this way turn off the bearing on the tumbling shaft without the work itself revolving.

Fig. 14 is a small tin hood, with an air jet in the apex. Oily valve parts are held under this and thoroughly cleaned by compressed air, without the use of waste, the hood keeping the oil from spattering all over the shop.

Fig. 15 shows a triple air-valve testing machine used by Wm. J. Bryant, in the air hose department. This machine is not operated by a brake valve, but by ¾-inch stop cocks and a 1/64-inch by-pass valve.

It is simple and quick in its work and readily shows the following defects or operations: Leaky valve body or bushing or any of the parts, and the running lap surface and emergency position for any of the standard triple air valves.

Valves may be removed from machine with train line and auxiliary full charge without loss of air and may be recharged in five seconds. Triple can be attached, tested and removed in two minutes.

Fig. 16 is operated the same as the machine just described, but is used for engine and tender triples.

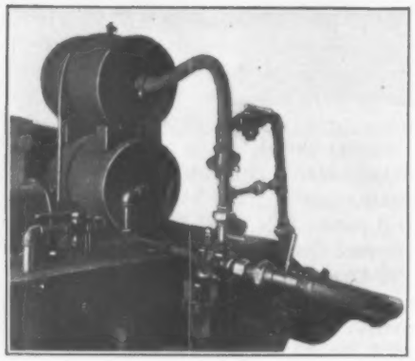


FIG. 15. TRIPLE VALVE TESTER
FIG. 16. TESTING ENGINE TRIPLES

WELDING LOCOMOTIVE FRAMES

The blacksmith foreman, C. T. Miller, has made quite a reputation for himself in railroad circles, by his success in welding broken locomotive frames. One frame he showed me he had welded over two years ago and though it had seen hard service it was as good as a new frame.

By his method, a locomotive frame is welded without dismantling the engine or removing it from the rails.

The heating apparatus used is shown in Fig. 17. The fuel used is crude oil with air at 100 pounds pressure.

The oil is fed by gravity from a tank

FIG. 17. OIL BURNER FOR LOCOMOTIVE FRAME WELDING

through a ⅜ pipe, the air pipe being ½ inch.

The great difference between Miller's burner and others is in the "Bunsen" style of auxiliary air supply on the end of jet as shown. It is this attachment that gives the enormous heat developed.

The way the frame is bricked in at the break in order to hold the heat and direct it where it is needed, is shown in *A* and *B*, Fig. 18.

By building a furnace like this, the heat is thrown where needed and the oxidizing effect of a direct flame is done away with.

A frame is raised to the right heat in from forty-five to sixty minutes, and is welded without flux of any kind, a ram being used to butt the broken ends together when the welding heat is reached.

Molding Air Cooled Cylinders

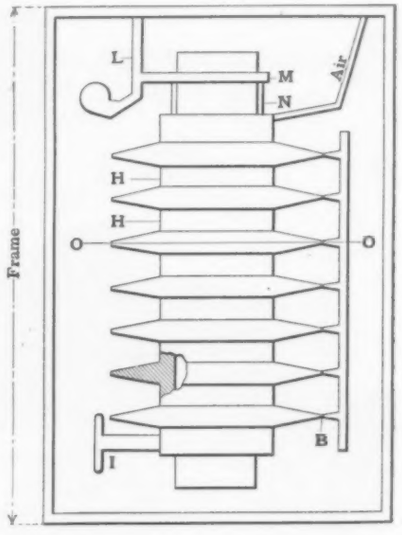
BY JOSEPH F. HART

Once on a time a foundryman undertook to make a lot of these castings, molding them in green sand and casting them on their sides. All he could make in this manner was scrap and he finally gave the job up.

Some time afterward this gentleman learned that similar castings had been successfully made for a number of years, by forming the mold in dry-sand cores and standing them on end before casting.

Adopting this method Mr. F. made small quantities of cylinders with splendid success. But he had learned something about the cost of castings and at the then current selling prices, felt that he ought to give the other fellows a chance to make some money.

Another foundryman mounted his air-cooled cylinder patterns on stripping-plate molding machines and made them in dry-sand molds. This fellow came mighty near



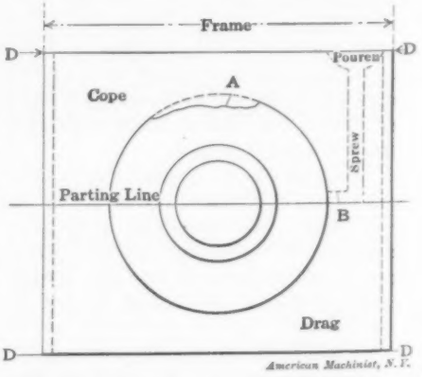


FIG. 1. AIR-COOLED CYLINDER MOLDED ON SIDE.

making the high mark, but not knowing this story he cast them on their sides.

Personally I don't believe these castings can be made in green sand with any degree of success. At *A* in Fig. 1 is shown the most common cause of loss, when they are cast on their sides.

The principles involved in the case are as follows: The iron entering each rib at *B*, fills the mold half full without much trouble. Above the level of *B*, however, the metal, as it rises, is constantly getting cooler on top. Added to this is the fact that before casting, the mold was full of air which has little chance to escape except by being forced through the sand of which the mold is made.

Thus we find that when the iron reaches the point *A* the deadest iron in the mold is trying to reach the point of a wedge in spite of the chilling effect of the mold on two sides and a cushion of compressed air.

In a green-sand mold there is also a certain amount of steam generated, and the chilling effect too, is greater in a green-sand mold than in one made of dry sand. But even if made in dry-sand molds, if these cylinders are cast on their sides, the loss is great and it is really a shameful extravagance.

The method of molding these cylinders in cores is shown in Fig. 1. Each half pattern is mounted on a board, inside of a frame of sufficient depth, with gate patterns if desired. Male and female bearings, or guides of some description, must be formed in each half core to insure proper matching when assembled. After these outer cores have been dried, the internal cores are set and the whole pasted together. A plate or board must be placed at the back of each outer core as at *D*, and the two clamped together before standing them on end to cast. One shop used to build a pouring basin of green sand but that made extra work and added to the chances of dirt getting in the mold, therefore the pouren should be formed in the cores and finished as neatly as any part of the mold.

In actual practice this method reduces the loss to a minimum, but the process is rather expensive and there is a needless waste of material, although for small orders or samples of irregular sizes or shapes it is very handy, because the only especial rigging needed is a planed pattern board, with guides properly placed. Anything will do for the frame or sides of the core box; a slip over for a snap flask would be really good enough though, of course, where facilities are at hand, it is as well to do things in the right way.

In part of Fig. 1 and in Fig. 2 can be seen how these patterns were mounted on a molding machine and made in flasks. The plate *E* was, of course, cut to the outline of the pattern, sections *H H*, etc., were fastened to this plate and remained stationary, while the air-cooling ribs were drawn through them. In this instance the molds were dried and cast on their sides, the castings being gated (when the ribs were heavy enough) at *B*. In other cases where the ribs were too thin to allow a gate, the castings were gated in four places as at *I*.

By this method the molding cost is reduced to one-third or less of the cost of the same when made in cores, and the amount of new sand required, when the molds are made in flasks, is hardly one-tenth of the quantity required when the core method is used. Also when the pattern is drawn through a stripping plate it leaves a much better mold than is possible to get by other methods. Next to the stripping plate comes the vibrated pattern, guided by the flask pins. The roll-over machines and hand-drawn patterns are on

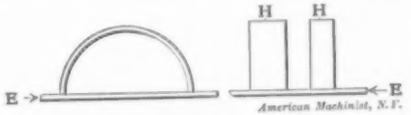


FIG. 2. STRIPPING PLATE

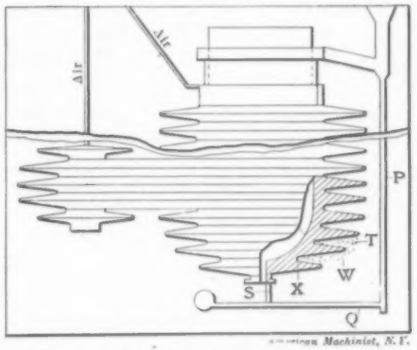


FIG. 3. AIR-COOLED CYLINDER MOLDED ON END

an equal footing, being far inferior to the first methods mentioned.

Now a peculiar thing to me is, that the fellow who first used the core method couldn't see the economy to be gained by using flasks, for his other ideas were a success from the start. The man who put them on the machine is excusable in a way, for it is only another case of an enthusiast over molding machines who lacked the practical knowledge of molding necessary to obtain the best results. Had the gentleman in question only known of the previous success obtained by casting the cylinders on end, he might have saved some few thousand dollars of good American money, which he has paid for the trouble of making his own scrap instead of buying it outside.

Generations ago it was generally recognized in the foundry trade that the best method of making hollow cast-iron cylinders which had to be bored was to cast them on end and drop the iron from the top. In Fig. 1, *L*, *M* and *N* show how to arrange the gate for the air-cooled type in all cases where the iron can drop right clear to the bottom of the mold without striking any of the ribs of sand. *N* should be about 1/16 inch thick where it joins the casting; on cylinders 3 inches in diameter or less *N* should be continuous all around the core; on casting of greater diameter it can be divided into gates about 2 inches wide, with an inch of sand between them. By the method of gating the metal drops right along the core in a thin sheet, and it will be readily seen that as the mold fills each successive rib has a fresh supply of the hottest iron, also that if the line *O O* be horizontal there are no pockets for the air to get confined in.

In Fig. 3, *P*, *Q* and *S* show how to introduce some metal at the bottom of the mold when it is necessary. In this case the iron from the top would strike the sand tooth at *T*, so the mold must be filled from the bottom until the point is covered and then finished from the top. In all cases the gates should be made so that the first dash of iron passes by without entering the mold. The first iron gives its heat up to the gates and generally gathers a little dirt on its way. Air vents should be provided as shown.

Some time ago one of your correspondents asked what sand should be used for molding these cylinders, thinking probably that the sand was the cause of all the wasters, and there are still some people experimenting under the same impression. Almost any foundry sand will do if used intelligently. French sand is good but unnecessary on this class of work; domestic molding sands are used straight by mixing with linseed oil; they are also used when mixed with any very fine, sharp sand in varying proportions. Any very fine, sharp sand can be used alone, if enough oil is used to harden it.

Medium coarse grades of Hudson river sand, of good quality, can be used in two parts of new sand to one from the molding floor, if mixed with molasses water and a little salt; this latter is probably as good as any sand for the purpose. In all cases the sand should be dried and put through a fine sieve before mixing. This, of course, applies only to the sand used as a facing. The molds should be sprayed with a light wash of either talc or black lead, by using a blow can.

Any sand mixture containing oil as a binder needs a lot of drying, generally over night. A straight molding sand of proper texture, if mixed with molasses water, or compounds of a similar nature, can be skin-dried in from 15 to 30 minutes, if exposed to temperatures ranging from 150 to 200 degrees Fahrenheit. The addition of small quantities of common salt to the mixture makes the molds harder when dried.

The best way to skin-dry these molds is to have small ovens on the floor where the molds are made; ovens large enough to hold an hour's molding would have room to spare. In skin-drying by other methods than in ovens the heat fails to reach the base of the sand teeth at *W*, while the delicate points at *X* are apt to become burned.

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Belted or Geared Feeds

Fashions are not confined to women's bonnets, but exist to greater or less extent in many branches of engineering, and while the machine-tool industry is, perhaps, less affected than locomotive design and other lines, there is still a tendency to follow styles set by successful builders.

Geared heads or constant-speed machines have become very common and geared feeds are being used on almost everything from the small engine lathe to the large miller. This came naturally as a result of the reaction against the old belt feed, especially on the lathe, where an inch belt, running so slowly that you had to look twice to make sure it was moving, was expected to pull the tool into the cut. While this answered fairly well when we nibbled away with light cuts, the introduction of mushet and the high-speed steels left it with but one good point—it made a safety valve that would slip when the load was too heavy.

The use of geared feeds on milling machines gave us our first ideas of what might be done in the way of removing metal, and established results that were almost undreamed of in the old days, while on rapid-reduction lathes equally good performances were made possible by the same devices.

This makes what seems to be a "reversion to types," in other words, a return to belt-driven feeds in heavy milling-machine work, all the more surprising to those who follow closely the development along this line. It is a fact, nevertheless, that some of the largest and most conservative builders of heavy machines are going back to the belt-driven feed in their latest machines.

This is not merely a whim nor notion of the designer, the day for that having passed in most shops, but is the result of critical tests with cutter and machine driven practically to the limit of endurance. Some of the best records of metal removal that have yet been accomplished were obtained on a new machine with a belt-driven feed. Not of the old, narrow, slow-moving type, to be sure, but a belt feed designed on modern lines, with large pulleys, a belt of ample width, and running at high speed.

In contrast to this we cite a test of another machine in which two sets of feed gears were stripped out in the endeavor to equal the record of the belt-driven feed, while the third and strengthened set of gears did not produce as good results.

Of course, gears can be made strong enough to give any feed that the cutter or work will stand. And, if the only advantage of a belt was in the tendency to slip a trifle under excessive strain due to a hard spot or unevenness of casting, this could be taken care of by a spring or flexible coupling somewhere in the train. But this is evidently not all. Both first cost and maintenance must also be considered and, with equal power, this ought to be found favoring the belt. For belts are daily transmitting hundreds of horsepower at a comparatively small cost.

As a verification of this and showing, perhaps, a modern tendency, we give an instance which recently came to notice. A good, practical shop man who had been responsible for the selection of all the machine tools was also put in charge of their maintenance with a somewhat curious and startling result. When he simply selected the tools, he would have nothing but gears in both heads and feeds. But when he became responsible for maintenance of tools as well as their selection and output, he soon began ordering nothing but belt-driven machines.

This does not mean going back to the old belt feeds, even if gears should be abandoned entirely, but rather the development of a new type of belt feed based on modern knowledge of both the work to be done and machine design. The old plans are entirely out-of-date, and if we should find that belts after all are better than gears, we cannot consider the use of gears as a mistake, but rather as a step that was necessary to rouse us to the possibilities of a better system of belt feeds.

High Steam Pressure in Locomotive Service

An evidence of the changes that are taking place in engineering practice and the way in which we swing to extremes, is shown by Bulletin No. 26 issued by the University of Illinois, which contains the report of Prof. W. F. M. Goss on the use of "High Steam Pressure in Locomotive Service." This is one of the many cases where railroad engineers have pursued false gods as they seem to do all too often, only to come back to a more rational ground after long and tedious trials and expense.

All those who have followed railroad work will remember the mad rush a few years ago after high pressures as well as the papers and reports showing the various advantages and economies that were being realized. Steam pressures were increased from 150 to 185, to 210, and even 240 pounds in a few cases with great savings according to reports. Many practical men pointed out the disadvantage as well as the expense of such a proceeding and now comes the careful report of Professor Goss which draws some very interesting conclusions.

According to the tests the difference in coal consumption per indicated horsepower-hour is only 0.69 of a pound between 120 and 240 pounds pressure, a drop from 4 to 3.31 pounds of coal. The higher the pressure above 160 pounds the less the gain in fuel, not enough to warrant the

extra cost of maintenance. And this saving will depend on the condition in which the engine is kept as well as on the pressure. The higher the pressure the better the condition necessary, and without this all saving is likely to disappear, leaving only the greater cost of maintenance that accompanies the higher pressure. His conclusions show that it is far better to increase the boiler capacity than the pressure, as this does not add to the cost of maintenance. A boiler of larger capacity may not weigh more than one built to withstand higher pressure and better results are sure to be obtained.

Assuming 180 pounds pressure as the highest that it is desirable to carry, and this requires the best kind of maintenance, it is better to increase weight by a larger boiler than to increase pressure. Unless the maintenance is of the highest order, 180 pounds is too high. When the water is bad, so as to foam or scale, the pressure should be less than 180 pounds.

A simple locomotive using saturated steam will render good and efficient service with 160 pounds running pressure, and there are no conditions so favorable or no economies to be obtained which justify the use of over 200 pounds pressure.

And so we see another of the railroad fads take a back seat for the time being, only to be rejuvenated in the next few years as a great discovery, if we can judge the future by the past, and we have no other way. Like other diseases they must run their course until increased cost of maintenance, difficulties of lubrication and other expenses become too great to be borne.

The Census of Manufactures

The provisions for the taking of the new census, insofar as it applies to manufactures, provides, first, that it shall be taken next year and every ten years thereafter.

The schedules relating to manufactures will be covered by inquiries as to the name and location of each establishment; character of organization, whether individual, coöperative, or other form; character of the business and the kind of goods manufactured; the amount of capital invested, the number of proprietors, firm members, copartners, stockholders and officers and the amounts of their salaries; the number of employees and the amount of their wages; the quantity and cost of the materials; the amount of miscellaneous expense; the quantity and the value of the products; the time in operation during the census year; the quantity and character of the power used and the character and number of machines employed.

Inquiries will be confined to manufacturing establishments which were in active operation during all or a portion of the year ending December 31 next, preceding the census year; and it will be confined to manufacturing establishments conducted under the factory system, and will exclude neighborhood, household and hand industries.

It will be the duty of those interested to answer all questions correctly, and any owner, president, secretary, director, or other officer or agent of any manufacturing establishment who shall refuse or neglect to answer or give false answers to any of the questions asked would be guilty of a misdemeanor, and upon conviction would be liable to a fine of not exceeding $10,000 or imprisonment for a period of one year, or both, at the discretion of the courts.

International Exhibition of Railways and Land Transport at Buenos Aires

Official announcement has been made of an exhibition covering all methods of land transportation to be held in Buenos Aires from May to November, 1910, in celebration of the 100th anniversary of the independence of the country. This would seem to offer an excellent opportunity for American manufacturers in the lines covered by the exposition, which, of course, include automobiles.

Full particulars relative to the exhibition may be obtained from the Argentine General Consulate, 80 Wall street, this city.

New Publication

MILLWRIGHTING. By James F. Hobart. 401 pages, 6x9 inches, 141 illustrations. Hill Publishing Company, New York and London. Price, $3, net.

Every shop or factory of almost any kind has more or less millwrighting work to do, even though the man who does it may not be called a millwright. This work includes the laying out of new buildings or extensions, the putting in of foundations for machinery, the use of the transit for locating definite points, putting up shafting and alining it, setting up new engines or machinery, and all sorts of similar work.

The author of this book has had years of practical experience just along these lines and he gives this in a way that is easily understood and that will be sure to help any young or inexperienced man along this line of work. While he does not pretend to make a civil engineer of the reader, he shows how the transit can be handled as much as is necessary in this kind of work. The mixing of concrete for foundations, the ways of testing it to be sure you are getting the best material, the framing of buildings, the making of molds of batters for concrete foundations, the strength of materials needed and used, the laying out of shafting, the use of belts and the power they should give, the handling of heavy machinery by tackle and skids, the setting of steam boilers and engines and the many other things that come under this line of work, are all treated in plain English, and the various points fully illustrated.

There has never been a book which covered just this field, and we believe this will be a welcome addition to the library of every man who has this kind of work in charge. And there is hardly a shop where it would not be a paying investment to have a copy of this at hand for occasional or frequent reference as the case may be.

Personals*

P. G. March, president of the Cincinnati Shaper Company, returned April 27 from a three-months' trip to Europe.

Edward C. Sawyer, who was formerly connected with the H. W. Johns-Manville Company, is now associated with H. G. Hammett, Troy, N. Y.

Herbert H. Morrison, formerly of New York City, has established himself as consulting engineer in St. Louis, Mo., with offices in the Syndicate Trust building.

William Osterholm, formerly with the Latham Machinery Company, has been appointed general superintendent of the Holm's Machine Manufacturing Company, Sparta, Mich.

John Francis Buckley, formerly superintendent of the Witte Iron Works Company, has become general superintendent of the St. Marys Machine Company, St. Marys, Ohio.

Guy Larnard Meaker, until recently president of the Meaker Company, Chicago, Ill., has become assistant superintendent of the American Steel Wire Company's Rochdale Works, Joliet, Ill.

Frank J. McDevitt, for some time connected with the Carnegie Steel Company's works at Youngstown, Ohio, has recently become vice-president and manager of the Ohio Steam Specialty Company, Youngstown, Ohio.

George W. Durham has recently associated himself with the Hudson Motor Car Company, Detroit, Mich., and will act in the capacity of chief engineer. He formerly held a similar position with the Olds Motor Works.

Joseph H. Ames, chief engineer of the American Car and Foundry Company, who has up to recently been located at headquarters in St. Louis, Mo., is now acting in the same capacity with headquarters in Chicago, Ill.

At the regular council meeting of the American Society of Mechanical Engineers, held on April 18, there were appointed on the involute-gear committee Wilfred Lewis, Hugo Bilgram, Gaetano Lanza, Charles R. Gabriel and C. W. MacCord.

*Items for this column are solicited.

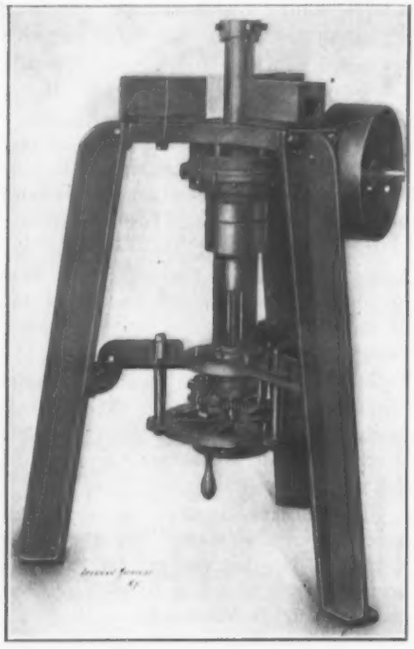
New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make it Possible To Do Better Work at a Reduced Cost

THE LATEST INFORMATION

Automobile Cylinder Reboring Machine

The illustration shows a machine designed for reboring automobile cylinders. It operates in a vertical position, and may be driven by a one-horsepower motor. The drive shaft meshes with a worm



AUTOMATIC CYLINDER REBORING MACHINE

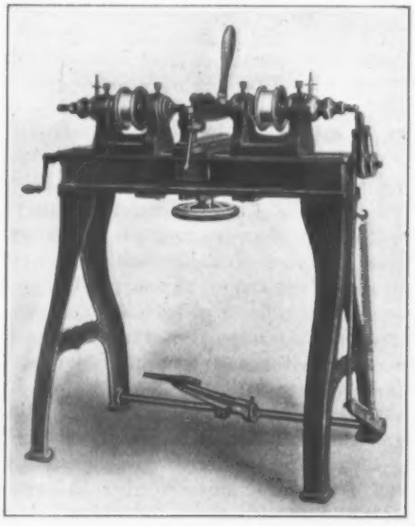
wheel which revolves the cutting spindle, the latter having a travel of about 15 inches. The spindle is equipped with an adjustable head which is used to center the cylinder and is then removed and the cutting tools substituted. The cutter head consists of four tools set out equally by a taper in the center and is thus readily adjusted for the depth of cut required. The feed is automatic, variable and reversible, having a star wheel engaging one or more operating fingers to suit requirements.

The cylinder to be rebored rests upon three adjustable sliding blocks which are planed true and at right angles to the spindle. Clamps hold the cylinder in place after it has been centered, and as it rests upon the same face which is bolted to the crank case, the original alinement is assured. It is immaterial whether the cylinders are cast separately or together; they may be rigidly held without distortion. This machine is also capable of boring as well as reboring and several may be used in the space which a large machine tool would occupy.

Inasmuch as most automobile cylinders are blind, it is only necessary to measure the length of cut required and note on the spindle below, the travel needed; the latter is graduated for this purpose. As the work is done in a vertical position, the chips fall out, do not clog the cutters or in any other way interfere with the work. Usually only one cut is required and this may be rapidly run through. The machine is built by H. B. Underwood & Co., Philadelphia, Penn.

Rivet Spinning Machine

This machine is equipped with two independent belt-driven spindles rotating in opposite directions. The spindle heads are adjustable to any length of rivet and the

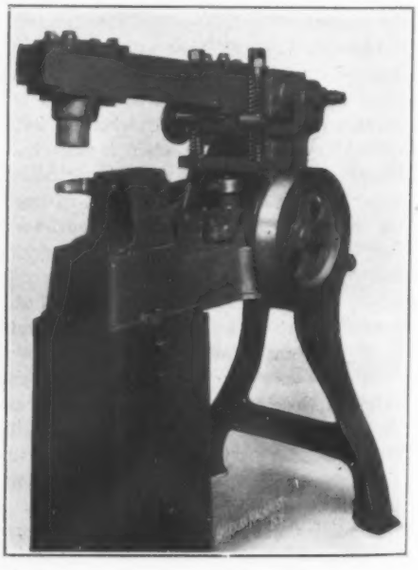


RIVET SPINNING MACHINE

stroke is adjustable to any desired size of head. The machine is equipped with a rest or support for the work, and a lever-operated clamp to hold the working plates on the support while spinning the head on the rivet. The support for the work is secured in position by means of the hand wheel at the center of the bed and the adjustment of the spindle heads is effected by means of the crank shown at the left-hand end of the bed. The bearings are of an adjustable cone type permitting wear to be taken up and alinement of the spindles maintained. The machine is made by Fritz A. Schulz, 66 N. Jefferson street, Chicago, Ill.

Power Hammer

The striking beam of this hammer is of hardwood tapering from 4x3⅛ inches on one end to 3½x3½ inches at the other. A box is mounted under the beam by a fork passing through the shaft; on this shaft which passes through the box are four springs mounted two on the lower and two on the upper part, thus cushioning is secured by these springs which are easily adjusted for any kind of work. An adjustment in the connecting rod enables the operator to raise or lower the head as the work may require. For metal trade the hammer is built with a horn attachment, the beam being supplied with a special gripping device to grip either a wooden, rawhide, or steel hammer. The power is applied by means of a foot lever which draws the loose pulley up to the belt, regulating the force of the blow by the pressure of the foot. The hammer weighs about 500 pounds, takes up a floor space of 24x32 inches, and will strike about 300 times per minute. The hammer is mounted on a wooden base, if so desired. The maker is Fritz A. Schulz, 66 North Jefferson street, Chicago, Ill.



POWER HAMMER

Horizontal Boring, Drilling and Milling Machine

The halftones show a No. 0 horizontal, boring, drilling and milling machine built by the Fosdick Machine Tool Company, Cincinnati, O. The machine is equipped with speed box and constant-speed motor, the speed box being of the tumbler-gear type and equipped with steel gears throughout. There are four changes made through the tumbler gears and two through the back gears in the speed box, making a total of eight changes of speed. The slow-speed change is made through a pair of tool-steel clutches, 4 inches in diameter, and the high-speed change through a powerful friction clutch, 5½ inches in diameter. These changes are controlled by a lever, shown in Fig. 1, running to the front of the machine, which can also be used to stop the machine. A 5-horsepower constant-speed motor operated at 1000 revolutions per minute, is used, geared direct to the drive shaft through a pair of spur gears, the pinion of which is of rawhide, brass bound. In using a variable-speed motor, the equipment is similar to that shown with the exception of the speed box and controller. A drum type controller is used with the variable-speed motor drive, and is mounted on the head where the speeds can be easily controlled from the front of the machine. The lever for starting, stopping or controlling the back-gear changes is in the same position as shown for the constant-speed drive.

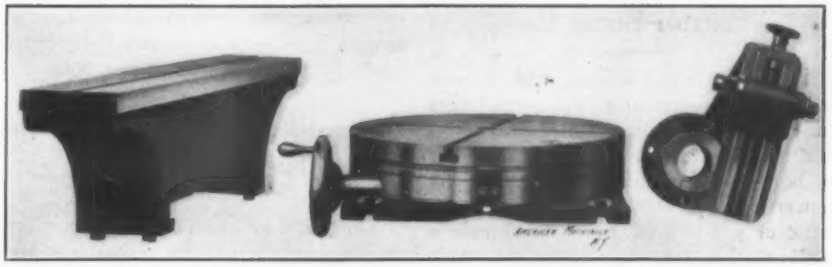


FIG. 2. ATTACHMENTS FOR HORIZONTAL BORING, DRILLING AND MILLING MACHINE

Fig. 2 shows a revolving table, an auxiliary table and a star-feed facing attachment. The latter is used for facing work up to 18 inches in diameter and can be bolted direct to the spindle sleeve, or securely clamped in any position on the spindle. The auxiliary table is used for any overhanging work, which can either be bolted to it or travel thereon. It is 8 inches wide, 48 inches long and provided with T-slots its entire length. The revolving table shown is a combination hand-swiveling and worm-swiveling table. The worm with its handwheel can be withdrawn, and the table used as a plain revolving table. The top platen has also four tightening bolts, which securely fasten the platen to the base plate, which in turn is tongued and bolted to the cross table. This table is graduated to half degrees; it is 24 inches in diameter, 6 inches high and has an accurately bored center hole for arbors or plugs as required. The top surface has four cored T-slots.

A Heavy Duty 21-inch Drill Press

This has been designed with a view to meeting modern conditions that demand a machine that makes it possible to use high-speed drills to the best advantage. As an evidence of the work that can be done by this drill, a recent test at the mechanical and electrical exhibition in Worcester, Mass., the operator was unable to stall the machine with the hand feed and he drilled seven ⅝-inch holes, each 1⅛ inches deep, in cast iron in 30 seconds.

The drill is furnished for either belt or motor drive, a 1-horsepower General Electric motor being supplied. The drive is by belt on the four-step cone in either case. Power feed is taken from the small cones and through the double worm gearing shown. Hand feed is either by lever direct, or by the hand wheel and single-worm gear. It is designed to drill up to 1¾-inch diameter in cast iron, has 8½ inches spindle feed, No. 3 Morse taper in spindle, and a table movement of 16½ inches. It is made by G. E. Snyder & Son, Worcester, Mass.

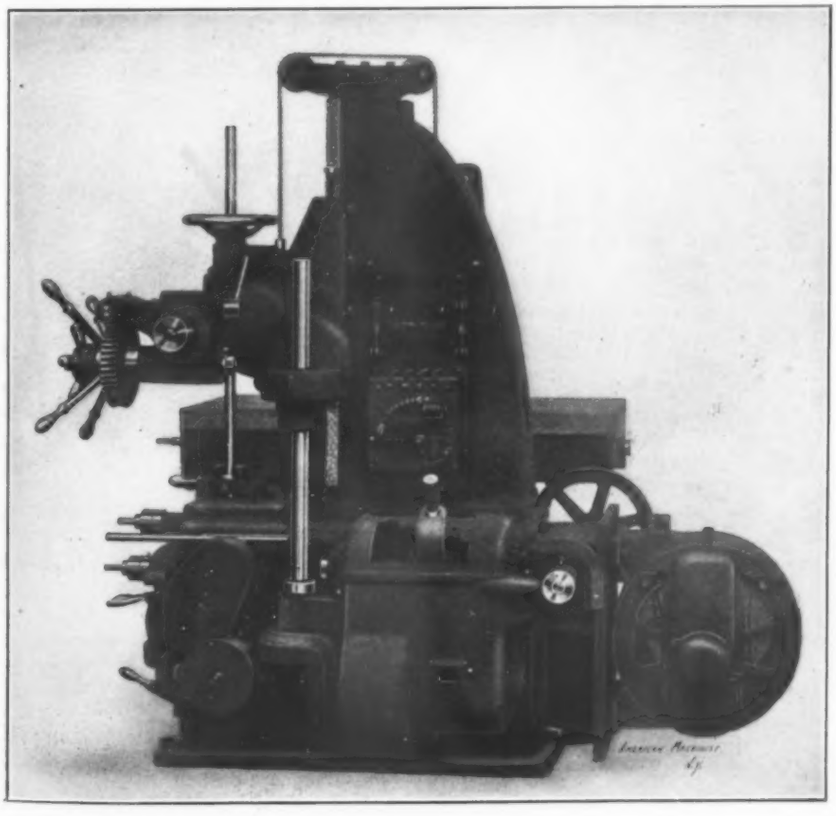
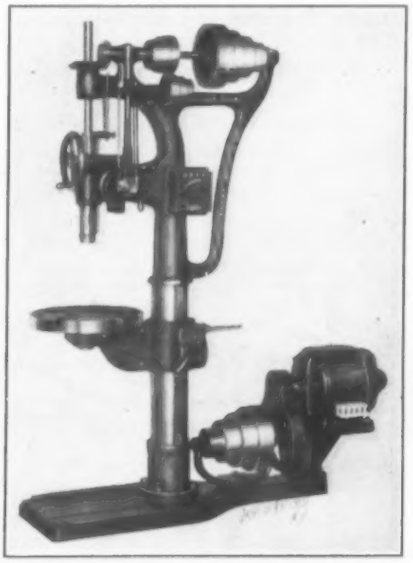


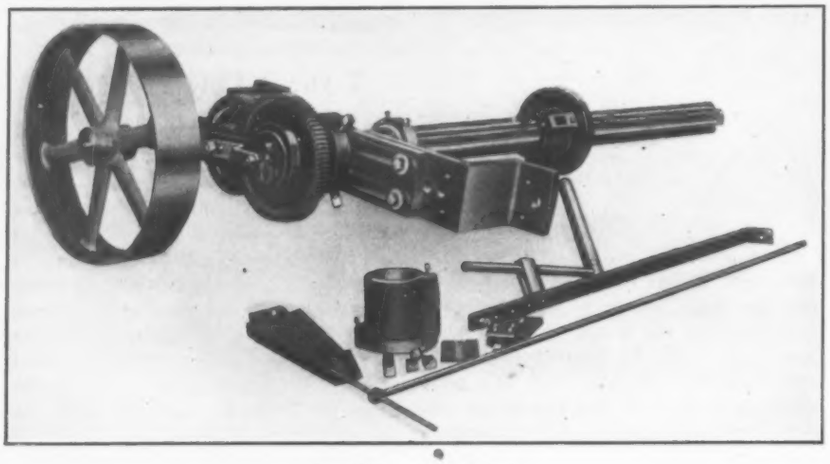
FIG. 1. HORIZONTAL BORING, DRILLING AND MILLING MACHINE



HEAVY DUTY 21-INCH DRILL PRESS

Portable Boring Bar

This portable tool is being made in sizes to rebore cylinders up to thirty-six inches in diameter. Enough cutter-head arms and tools are furnished with each size bar to bore several diameters. The bars are powerfully geared and can be driven by hand or power. The steel feed screw is set in the bar, insuring rigidity and steady feed. The feed nut is made of brass with a square thread of eight pitch, to insure long life.

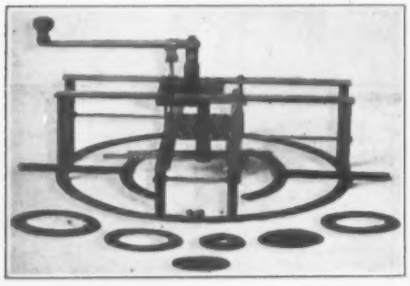


PORTABLE BORING BAR

The principal features are compactness, strength and simplicity in construction. They are made by the Nappanee Iron Works, Nappanee, Ind.

A Substantial Gasket Cutter

This appears to be a much more substantial machine than is usually found



A SUBSTANTIAL GASKET CUTTER

for this purpose and it has the advantage of handling either round or oval shapes, as may be desired. The knife is fed automatically into the material, cutting the outside of the washer first and then the inside. The material is held firmly under the knife by the roll at the end of the arm. The motion for oval washers is obtained by a combination of a crank and the two slides. A glass cutter can be used in place of the knives and its scope of usefulness greatly increased. The machine shown is made in two sizes, one cutting from 1 to 10 inches, the other from 4 to 21 inches, round or oval. It is made by J. A. Rose, Hastings, Neb.

Automatic Grinding Machine for Inserted-tooth Saw

The halftone illustrates a new automatic grinding machine which has been developed by the Newton Machine Tool Works, Inc., Philadelphia, Penn. for grinding the "Premier" inserted-tooth cold-saw blades. This machine consists, as shown in Fig. 1, of a substantial base onto which is fitted a saddle carrying a spindle, driven through worm and worm wheel by a cone giving four changes of speed. The front end of the spindle carries a head arranged as in Fig. 2 with a locating center and with two clamping bolts onto which the saw blade with the teeth inserted is bolted. After the saw blade has been clamped in place the saddle, mounted on the front of the machine for carrying the grinding wheel, is adjusted to bring the finger operating the eccentric bearings into engagement with the top of the saw tooth, as shown in Fig. 3. Rotation of the blade lifts the finger, in turn rotating the eccentric operating the oscillating arm on which the

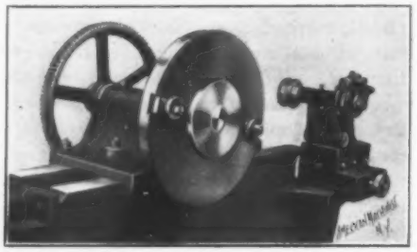


FIG. 2. HEAD FOR HOLDING SAW BLADE AND EMERY-WHEEL HEAD

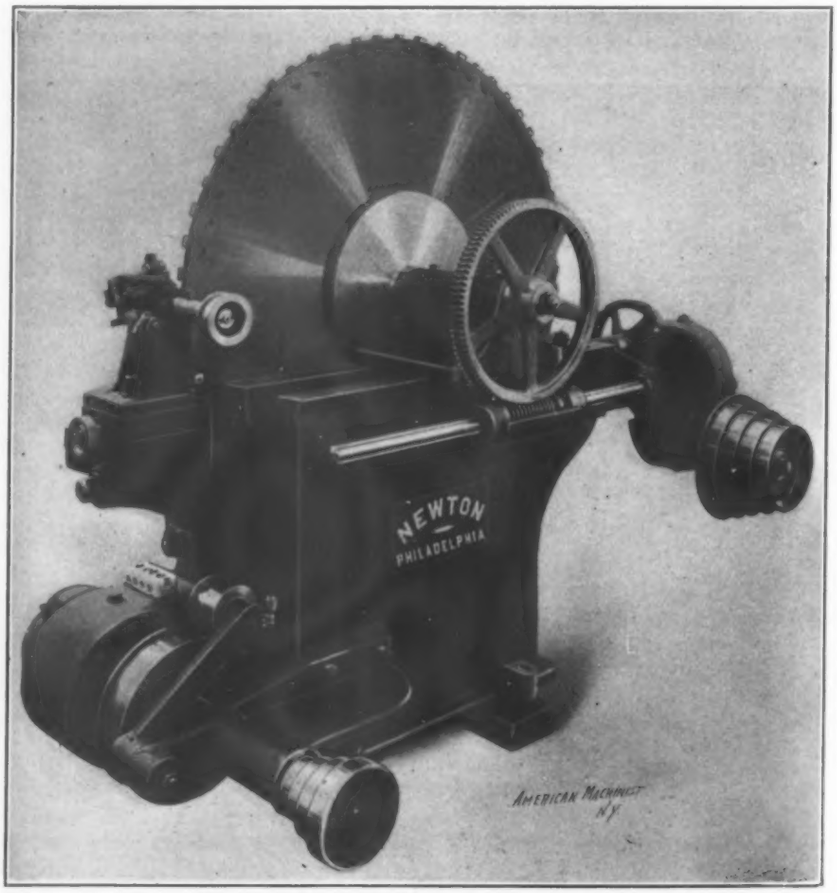
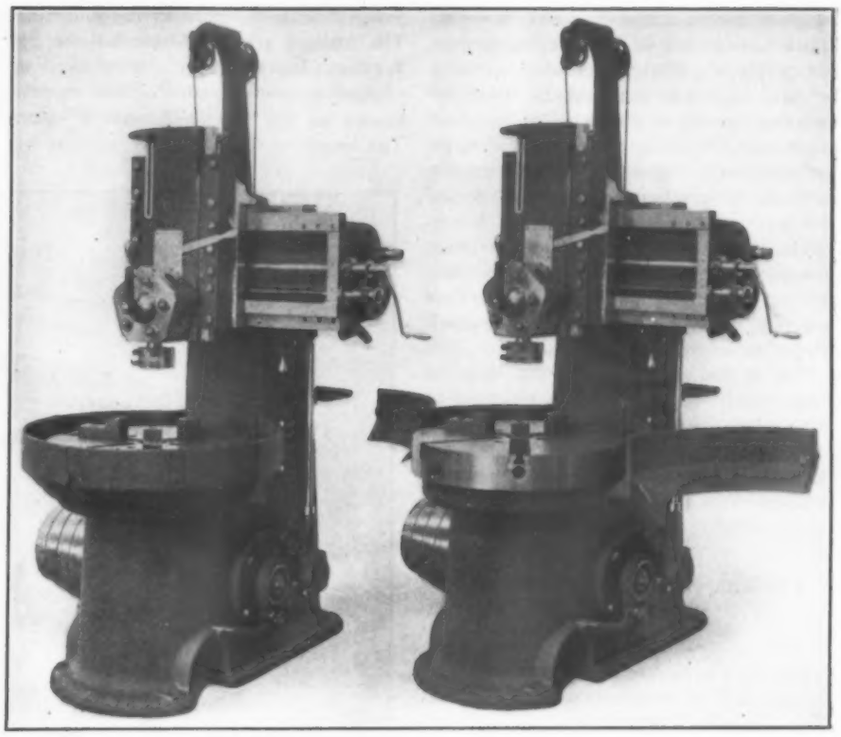


FIG. 1. AUTOMATIC GRINDER FOR INSERTED-TOOTH COLD SAW

emery wheel is mounted. As the finger is drawn upward the emery wheel is forced nearer the center of the blade, thus grinding face clearance. The release of the blade is obtained by the contraction of the spring shown. As it is also necessary to grind the side rake and radial clearance, the compound slides are arranged with three distinct swiveling centers, each practically in line with the center of the emery wheel. In grinding the side clearance the elevation of the arm engaging the tooth gives side movement to the slide carrying the emery wheel for grinding this clearance. The drive is by means of motor as shown in Fig. 1. The machine has a capacity for saw blades from 24 to 60 inches.

FIG. 3. THE GRINDING-WHEEL HEAD



CHIP AND LUBRICANT GUARD FOR BORING MILL

Water or Oil Guard for Boring Mills

This has been designed to allow the use of lubricants in boring-mill work without having the water or oil fly all over both the operator and the floor. It extends both above and below the chuck and yet is not in the way of the chuck jaws or of a wrench for clamping the work in place.

This guard consists of four pieces, two being supporting brackets for the wings, and are bolted to the sides of the column as can be seen. The wings are so hinged as to open out as shown and leave the whole front of the table clear.

A trough can be attached below the guard to catch the chips and lubricant and carried off, or they can be allowed to fall into a pan surrounding the base. It is made by the Colburn Machine Tool Company, Franklin, Penn.

Two Machines for Fine Work

The first of these, Fig. 1, shows a machine for turning small cutters and backing them off. While specially designed for watch and clock machines it will handle cutters up to 2½ inches in diameter and of 24 diametral pitch, or coarser if the diameter is less. A cam on the driving shaft connects to the lower cross slide and gives the movement for backing off or relieving the cutter. The cam shaft is driven by a train of gears so that by changing the gears any number of teeth from 4 to 16 may be backed off with the regular equipment. The depth of cut can be gaged by a handwheel graduated to 0.0005 of an inch.

It can also be used for forming master cutters. The cross-slide movement can be stopped by turning a small lever and by clamping the lower slide; the others can be used as a compound rest. The bed is an arc with its center identical with that of the work spindle so that the headstock may be reversed at will. This allows one side of a cutter to be formed with the headstock in one position and by reversing the work and headstock, the other side can be turned by the same tool so that both sides will be exactly alike.

A clutch-cutting machine for stem-winding watches is shown in Fig. 2,

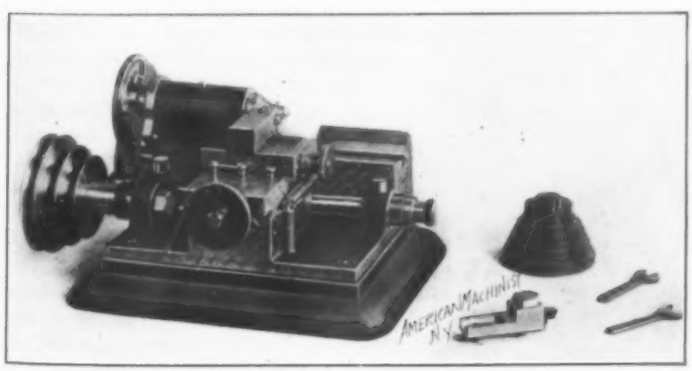


FIG. 1. MACHINE FOR TURNING AND BACKING OFF CUTTERS

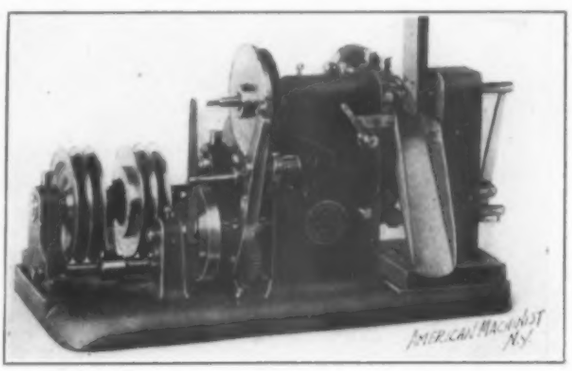


FIG. 2. WITH MAGAZINE FEED

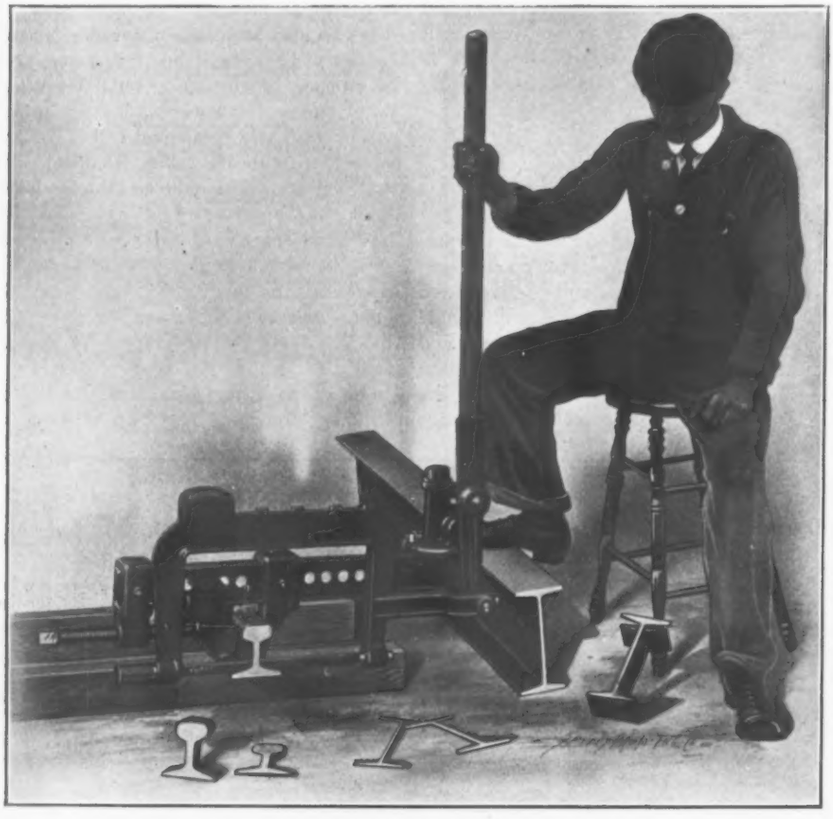
equipped with a magazine feed. A spring chuck is provided in the indexing spindle for the blank. While the head is normally at right angles to work spindle it can be swiveled enough to give a slight undercut when desired. The work can also be swiveled for 5 degrees to each side of the vertical, to give an angular cut to the clutch.

The machine is arranged to cut twice around the work so as to remove the bur left on the top of the teeth from the first cut, the second cut being made at a much higher speed than the first.

This is made in two styles, one with the magazine feed and the other arranged to stop at the completion of the last cut so that the next piece can be put in by hand. They are both made by the Waltham Machine Works, Waltham, Mass.

Portable Hack Saw Machine

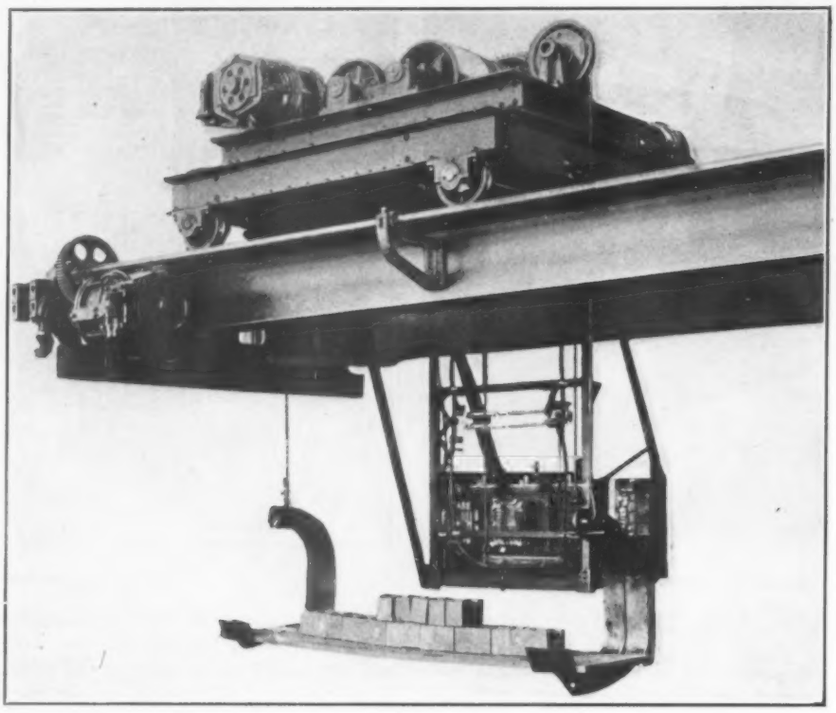
This portable machine is well illustrated by the accompanying halftone. As indicated, it is especially adapted to cutting off rails, I-beams, etc., and will cut through rails or beams up to 9 inches at any angle to 45 degrees. When set up ready to operate it weighs about 90 pounds. The method of attaching to the work and operating is clearly shown, as is also the means of setting for cutting off at an angle. It is stated that with this apparatus a man can readily cut through a 9-inch I-beam in from 25 to 30 minutes. The makers are the Massachusetts Saw Works, Chicopee, Mass., who have developed a special blade for the machine, known as the "Victor Special P" blade. The length of the blade used is 14 inches.



PORTABLE HACK-SAW MACHINE

Electric Traveling Scale Crane

The accompanying halftone illustrates a new type of scale crane, designed and manufactured by the Whiting Foundry Equipment Company, Harvey, Ill. All movements are operated by electric power. The novel feature of this crane consists in the application of the scales for weighing material which are supported on the trolley-truck frame and carry the hoisting mechanism mounted on independent steel framework. The scale beams are in the cage suspended from the trolley and readings are taken and recorded by the operator. There are three beams: two scale beams with self-recording poises and one tare beam, enabling weights to be determined of several different items of material with ease and accuracy. A simple movement of a hand lever transfers, when desired, all load from the knife edges of the scale to the trolley-truck frame, and then operation is the same as with the ordinary trolley. An open-side platform is furnished, as shown, for carrying long pieces such as rods, bars, etc, The design of this platform is made to suit the material to be handled. A crane of this type is useful in loading material, checking invoiced weights, and in loading for shipment, for inventory, etc.



ELECTRIC TRAVELING SCALE CRANE

Six of these cranes, five tons capacity, 37 feet 10¾ inches span, operated by alternating current, have just been completed by the above company for the new warehouse of the Scully Steel and Iron Company, Chicago, Ill.

Combined Punch and Shear

At page 634 was illustrated a combined punch and shear made by Jannell Machine Company, Rumford Falls, Maine. This machine is made in both hand and power types, the latter having no ratchet, as in the case of the hand machine. The power machine weighs 3800 pounds, shears 4 inches by 1 inch, punches ¾-inch hole in ¾-inch iron, or ½-inch hole in ½-inch iron. It is driven by a 3-inch belt.

Inspector of Weights and Measures

The United States Civil Service Commission announces an examination on June 2, 1909, to secure eligibles from which to make certification to fill one or more vacancies in the position of assistant physicist (qualified as inspector of weights and measures) in the Bureau of Standards, at salaries varying from $1400 to $1800 per annum, and vacancies requiring similar qualifications as they may occur.

The duties in connection with the position will include the investigation of the laws and practice of inspection of weights and measures of the United States and other duties similar to those of assistants in physical and engineering laboratories. The service will involve extended trips in various parts of the United States. The appointment will be for one year, subject to reappointment if the work is continued.

The examination will consist of the subjects mentioned below, weighted as indicated:

	Subjects.	Weights.
1.	General physics	25
2.	Special subject: Inspection of weights and measures. This will include (1) special questions in the theory of the instruments and apparatus used in weighing and measuring and (2) practical questions on weights and measures with special reference to existing laws	35
3.	Education and experience (rated on application)	40
	Total	100

Applicants must show in their applications that they have been graduated or are about to be graduated from colleges or technical schools, or that they have attained an equivalent education or training, and must have had some experience in weights and measures administration.

Age limit, 20 years or over on the date of the examination.

This examination is open to all citizens of the United States who comply with the requirements.

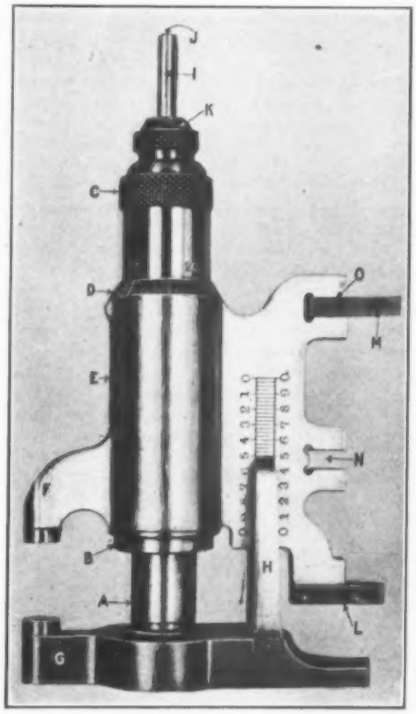
Applicants should at once apply to the United States Civil Service Commission, Washington, D. C., for application form 1312. No application will be accepted unless properly executed and filed, in complete form, with the Commission at Washington, prior to the hour of closing business on May 22, 1909. In applying for this examination, the exact title, as given at the head of this announcement, should be used in the application.

A Handy Micrometer

By H. E. Curtis

Some time ago I made a micrometer which is shown in the accompanying illustration. It weighs six and one-half ounces, and for an all-round tool I find it very handy.

The base is flat on the bottom and has a stem *A*, upon which slides the sleeve *B*, turned by the nurled head *C*. The graduations at *D* read to half-thousandths. The sleeve carries the body *E* on which there is a projection *F*, which corresponds with



A HANDY MICROMETER

a projection *G* on the base. These projections have hardened anvils, the lower one of which may be adjusted from the under side of the base with a screwdriver. The opposite side of the body is guided between uprights *H* on the base. The top of one of these uprights acts as a line by which are read the revolutions of the screw. The graduations as stamped on the side of the body read down for the micrometer and up for the depth gage and hight gage.

The depth gage consists of a needle *I* which has a shoulder at *J*. Chuck *K* is loosened and the needle is allowed to drop through a hole in the base as far as it will go with the shoulder resting against the jaws of the chuck and then held by binding the chuck. When the micrometer is open 1 inch, the needle will be just flush with the bottom of the base. This will, of course, give 1-inch movement to the needle. The needle can, however, be clamped at any desired point and the top end used for a hight gage for setting the heads of a planer or making any other similar measurement. The step *L* is ⅛ inch thick and when the micrometer is down to zero the step drops into an opening in the base which at that point is also ⅛ inch thick. Measurements can be easily obtained with these parts by deducting 0.125 inch from the reading for the outside measurement, and adding 0.125 for inside measurements. When block *M* is in slot *N*, the range is from 1 to 2 inches and when in slot *O* as shown, the travel is from 2 to 3 inches.

This instrument is accurate for all measurements within its scope.

Forthcoming Meetings

American Supply and Machinery Manufacturers Association, joint convention with Southern Supply and Machinery Manufacturers Association, Chattanooga, Tenn., May 5, 6, 7; headquarters, Hotel Patten.

New York and New Jersey branch, National Metal Trades Association, monthly meeting, May 11, 30 Church street, New York City.

National Supply and Machinery Dealers Association and American Supply and Machinery Manufacturers Association, joint convention, Pittsburg, Penn., May 12-13-14, headquarters Fort Pitt hotel. A. T. Anderson, secretary, Wade building, Cleveland, Ohio.

The Foundry and Manufacturers' Supply Association, convention, Cincinnati, Ohio, week of May 17.

National Association of Manufacturers, fourteenth annual meeting, Waldorf Astoria hotel, New York City, May 17; George S. Boudinot, secretary, 170 Broadway, New York City.

American Foundrymen's Association convention, Cincinnati, Ohio, May 18-20, headquarters Hotel Sinton. Richard Moldenke, secretary, Watchung, N. J.

National Machine Tool Builders' Association, spring meeting, May 25,26, Milwaukee, Wis., headquarters, Plankington house. P. E. Montanus, secretary, Springfield, Ohio.

American Hardware Manufacturers Association, joint convention with Northern Hardware Jobbers Association, Pittsburg, Penn., June 9-11, headquarters, Hotel Schenley. F. D. Mitchell, secretary, 309 Broadway, New York City.

Railway Master Mechanics Association, annual convention, June 16-18, Atlantic City, N. J. Jos. W. Taylor, secretary, Old Colony building, Chicago, Ill.

Master Car Builders Association, annual convention, June 21-23, Atlantic City, N. J. Jos W. Taylor, secretary, Old Colony building, Chicago, Ill.

American Society of Testing Materials, annual meeting, June 29, Atlantic City, N. J. Edgar Marburg, secretary, University of Pennsylvania, Philadelphia, Penn.

Business Items

Muralt & Co. has opened a branch office in the Temple Court building, corner Bay and Richmond streets, Toronto, Ontario. J. Engd will be in charge as manager

Business Opportunities

The Ohio Forge Company Cleveland Ohio, is building a machine shop.

The Termaab & Monahan Co., Oshkosh, Wis., is in the market for several lathes.

The Anderson-Lacy Headlight Company, Houston, Texas, is to erect a new plant.

The Max Ams Machine Company, Mt. Vernon, N. Y., is to build a $20,000 addition.

The Mensching Brass Foundry Company, Milwaukee, Wis., will build an addition to plant.

The tannery of E. A. Fisher & Co., Bethel, Vt., was destroyed by fire. Loss, about $150,000.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., will build a three-story addition.

The Lutweiler Pumping Engine Company, of Los Angeles, Cal., is to move to Rochester, N. Y.

The Malleable Iron Range Company, Beaver Dam, Wis., will put up a new factory and foundry.

The American Metal Door Company, Jamestown, N. Y., is planning the erection of a new plant.

The Manitoba Rolling Mills Company, Winnipeg, Man., will spend $200,000 on extension to plant.

The Soo Railroad will probably erect shops at Moose Lake. General offices are Minneapolis, Minn.

The Jewett Typewriter Company, Des Moines, Iowa, will establish a factory in Birmingham, England.

The plant of the Ypsilanti (Mich.) canning factory was burned, causing a loss of about $11,000.

The La Crosse (Wis.) Hay Tool Company is having plans prepared for a plant at Chicago Heights Ill.

The Guy L. Sintz Engine Manufacturing Company, Marshall, Mich., has decided to erect a new plant.

The Speedwell Car Company, Dayton, Ohio, will erect a large addition to its automobile plant at Edgemont.

The Weston-Mott Company, Flint, Mich., manufacturing automobile parts, is building an addition to plant.

The Thor & Kabat Gas Engine Co., of Manitowoc, Wis., is contemplating the removal of its plant to Lena, Wis.

The Philadelphia (Penn.) Roll and Machine Works has let contract for the erection of a new roll and machine shop.

Fire destroyed the power house and tipple of the Maynard Coal Company, at Cannelville, Ohio. Loss, about $15,000.

L. F. Grammes & Sons, Allentown, Penn., propose erecting a new plant for the manufacture of machinery and supplies.

The Delta Bag Company, New Orleans, La., is said to be planning the erection of a large new plant to cost about $250,000.

The mill of the Patterson Lumber Company, Ratnier, Ore., was destroyed by fire, causing a loss of about $40,000. It will be rebuilt.

The Marshalltown (Iowa) Trowel Company is building two additions to plant. About $4,000 will be spent for tools and other equipment.

The Hanlon & Thornton Co., of North Attleboro, Mass., will erect a jewelry factory in Woonsocket, R. I., which is to employ 200 hands.

The Monon Railroad Company is to rebuild roundhouse burned at Bloomington, Ind., last fall. About $125,000 will be spent. General offices in Chicago.

The Union Tool Company, Los Angeles, Cal., manufacturing oil well tools, is planning the construction of another plant in the Fullerton oil field to cost $50,000.

The Roscoe, Snyder & Pacific Railroad Co. will erect machine shops and roundhouse at Roscoe, Texas. W. S. James, Roscoe, is assistant general manager.

The Trenkamp Stove and Manufacturing Company, Cleveland, Ohio, a recently organized concern, has made plans for the erection of plant to cost $75,000.

Contract has been let by the Texas & Pacific Railroad for roundhouse at Fort Worth, which is to replace the one recently burned. The new roundhouse is to cost $150,000.

It is announced that the Republic Iron and Steel Company, of Pittsburg, has planned the erection of a $10,000 000 open hearth plant at Lansingville, Ohio. Iron and steel pipe will be manufactured.

The Crouse-Hinds Company, Syracuse, N. Y., has secured site on which a new plant, comprising five buildings, is to be erected. The company manufactures switchboards, panel boards, switches, time registers, etc.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m., May 19, for screws, rivets, cotters, rasps and staples, belt hooks, hinges, padlocks, gaskets, torches, dry batteries, steam gages, grease cups, etc., as per Circular No. 507.

Proposals will be received until 1 p.m., May 26, 1909, for furnishing materials and supplies for the Picatinny Arsenal, Dover, N. J., for the fiscal year ending June 30, 1910, as follows: Felt, rope, steel, iron, hardware, oils, chemicals, laboratory supplies, electrical goods, etc. Full information can be had of the commanding officer.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m., May 17, for hand and push cars, warehouse trucks, scales, wheelbarrows, jacks, anvils, vises, forges, tool handles, blacksmiths', machinists,' carpenters' and track tools, drills, pipe tools, saws, differential, snatch and tackle blocks, etc as per Circular No. 506.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m. May 12, for steel, iron castings, tin, copper, brass, copper and brass tubing, chain, wire cable, rivets, bolts, screws, staples, nuts, stocks and dies, reamers, twist drills, bits, jacks, chucks, vises, wrenches, pliers, hammers, snatch blocks, valves, cocks, steam traps, steam whistles, lubricators, etc., as per Circular No. 509.

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open bids as follows: May 11—Coil springs (schedule 1203), electrical bells, fittings, arc lamps, supplies, lighting wire (schedule 1200); sheet brass, copper (schedule 1202); steel castings, steel (schedule 1201); sheet steel (schedule 1204), copper and brass pipe (schedule 1205), controlling valves (schedule 1204). May 18—Screw machine (schedule 1198).

New Incorporations

J. F. Friedel Paper Box Company, Syracuse, N. Y., has been incorporated. Capital, $30,000. Incorporators, J. F. Friedel, A. C. Friedel, M. C. Friedel.

The Reliance Speedmeter Company, Kittery, Me., has been organized to manufacture speedmeters, cyclometers, etc. Capital, $600,000. Horace Mitchell, Kittery, president.

The Lima Vacuum Cleaning Machine Company, Lima, Ohio, has been incorporated. Capital, $50,000. Incorporators, C. W. E. Boegel, George W. Harrison, A. L. White, etc.

Economical Shoe Machinery Company, New York, has been incorporated to manufacture shoe machinery. Capital, $30,000. Incorporators, H. B. Heyhman, C. E. Mundy, C. I. Hamilton.

George Damon & Sons, New York, incorporated to manufacture printing machinery. Capital, $100,000. Incorporators, A. M. Damon, W. S. Damon, Cranford, N. J., D. E. Damon, Brooklyn.

The Walsh Press and Die Company, Chicago, Ill., has been incorporated to do a general metal manufacturing business. Capital, $15,000. Incorporators, Frank L. Belknap, L. Force, Albert H. Graves.

The Federal Ice Machine Company, Portland, Me., has been organized for the purpose of manufacturing and dealing in cold-storage and refrigerating machinery. Capital, $5,000,000. A. F. Dunham, Portland, president.

The Franklin Wheel Company, Franklin, Ohio, has been organized with $50,000 capital by J. J. Weisner, of Miamisburg, Ohio, formerly general manager of the Bookwalter Wheel Company, of that place. Site has been purchased for plant.

New Catalogs

H. Gerstner & Sons, Dayton, Ohio. Catalog of tool cases. Illustrated, 3½x6 inches, paper.

Philadelphia Gear Works, 1120-1122 Vine street, Philadelphia, Penn. 1909-10 catalog of gears. Illustrated, 76 pages, 6x9 inches, paper.

The Bristol Company, Waterbury, Conn. Advance partial lists of recording pressure and vacuum gages. Illustrated, 24 pages, 8x10 inches.

Philadelphia Steel and Forge Company, Tacony, Philadelphia, Penn. Booklet of tool and die steel, rolled-steel bars etc. 20 pages, 3½x6 inches.

H. H. Franklin Manufacturing Company, Syracuse, N. Y. Pamphlet describing process of making die castings. Illustrated, 24 pages, 5x7 inches.

W. S. Rockwell Company, 50 Church street, New York. Bulletin describing rotary annealing and hardening furnace. Illustrated. 8 pages, 6x9 inches.

American Blower Company, Detroit, Mich. Handbook of information on blowers and exhausters for forges and furnaces. Illustrated, 24 pages, 3½x6 inches.

John Holroyd & Co., Perseverance Works, Milnrow near Rochdale, England. Bulletin of grinding and sharpening machines. Illustrated, 30 pages, 6x9 inches.

Lyon Metallic Manufacturing Company, Aurora, Ill. Bulletin No. 301-A, describing steel racks and adjustable shelving. Illustrated, 38 pages, 6x9 inches.

Wheeling Mold & Foundry Company, Wheeling, W. Va. Bulletin No. 102, illustrating and describing induction clutch reversing-drive for planers. 8 pages, 8x10½ inches.

Tindel-Morris Company, Eddystone, Penn. Bulletins 1 to 4 describing inserted tooth blades, cold sawing machines, crank shaft lathes, grinding lathes. Illustrated, 8x10½ inches.

American Specialty Company, 834 Monadnock building, Chicago, Ill. Catalog of high-speed drills and "Use-em-up" drill sockets. Illustrated, 24 pages, 5x7 inches, paper.

Montgomery & Co., 105-107 Fulton street, New York. Catalog No. 28, entitled "The Tool-Monger," showing tools, supplies and machinery. 288 pages, 4x6½ inches, paper.

Hill, Clarke & Company, 14 South Canal street, Chicago, Ill. Circulars describing and illustrating Chicago duplex hand miller and solid saddle miller, "Universal" horizontal boring, drilling and milling machine, with equipments sheets showing outfits A, B and C, Wood tilted turret lathe.

Want Advertisements

Rate 25 cents per line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E. G. Smith, Columbia, Pa.

Test indicators. H. A. Lowe, Cleveland, O.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Hand power bending tools, labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Light, fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

A large foundry and machine shop desires to add to present lines of manufacture. Box 126, AMERICAN MACHINIST.

Special machinery accurately built. Screw machine or turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

Machines designed; automatic, special. Practical working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia, Pa.

Light and medium weight machinery and duplicate parts built to order; tools, jigs, etc. MacCordy Mfg. Co., Amsterdam, N. Y.

Fully equipped machine shop will manufacture models; contract or day work. Menchen, 360 West 50th St., New York City.

A small but well equipped machine shop in Connecticut desires to add other devices to its present line. Box 164, AMER. MACH.

Wanted—Work for an up-to-date machine shop. We build all kinds of light machinery, dies, manufacturers' jigs, etc. M. J. Boyce, 584 Hudson St., New York City.

Lathe and machine work of every description, patterns, gear cutting, screw machine work, iron, brass and aluminum castings. The Sipp Electric & Machine Co., Paterson, N. J.

I have an excellent manufacturing proposition awaiting capital. Am ready and willing to demonstrate its merits to the right party. If interested, address "Rare Chance," Box 199, AMERICAN MACHINIST.

Tool holder—replaces any two holders now on market, can be used for boring and turning, also saver of labor and steel. For further particulars address "J." Box 24, Laurium, Michigan.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy ond Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMERICAN MACHINIST.

Proposals for Ordnance Supplies—Watervliet Arsenal, Watervliet, N. Y., April 17, 1909. Sealed proposals in triplicate, will be received until 1 p.m., May 17, 1909, for furnishing iron, steel, hardware, forage, fuel, oils, etc., during year ending June 30, 1910. Information furnished on application. Lt. Col. W. W. Gibson, Comdg.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Superintendent or general foreman, good executive, experienced in practical factory system and rapid manufacturing, desire change. Box 197, AMERICAN MACHINIST.

INDIANA

Wanted—Position as foreman; A-1 machinist and diemaker; large experience in foremanship; thoroughly understands punch presses; successful organizer; now employed, wish to make a change. Box 181, AM. MACH.

KANSAS

Mechanical engineer having broad experience as designer, superintendent and chief draftsman wants change. Technical training; shop practice and good executive ability. Box 180, AMERICAN MACHINIST.

MASSACHUSETTS

Who will pay $4.50 per day for a good foreman toolmaker? Box 183, AMER. MACH.

Position as manager or superintendent of machine works by experienced man. Box 173, AMERICAN MACHINIST.

Situation wanted as foreman of machine shop who has handled men successfully for nine years; experienced on high-speed machinery and tools. Box 185, AMER. MACH.

Mechanical graduate, 31, married, 4 years' shop, 4 years' drafting and superintending, inventive and energetic, desires responsible position in Middle West. Good references. Box 193, AMERICAN MACHINIST.

MICHIGAN

I want to correspond with a growing concern needing the services of an experienced man on tool or die work, as foreman or superintendent; have thorough knowledge of modern methods of producing duplicate parts economically. Box 200, AMER. MACHINIST.

NEW JERSEY

General foreman, excellent toolmaker and machinist, designer of labor-saving devices, open for engagement. Box 182, AM. MACH.

Competent designer (25) with nine years' shop and drawing room experience, wishes position as salesman or demonstrator. Box 169, AMERICAN MACHINIST.

NEW YORK

Draftsman, designer, experienced, seeks position. Box 191, AMER. MACHINIST.

Mechanical draftsman, technical graduate, seven years' experience mostly in automobile and gas engine, wishes position. Box 189, AMERICAN MACHINIST.

Up-to-date mechanical engineer, first-class mechanic, designer and shop engineer, with 12 years' experience, age 33, wants position. Box 192, AMERICAN MACHINIST.

By a young man as foreman or assistant to superintendent in a horse nail company. I have had twelve years' experience in the cold rolled process, with position for past two years as superintendent. Box 194, AM. M.

$3000 man desires change; five years in responsible position, large concern; successful record as executive, organizer and designer in engineering, manufacturing and inspection department; 15 years' experience light and medium interchangeable work. Box 170, AMERICAN MACHINIST.

Works manager or chief engineer; American mechanical and electrical engineer, with technical training strengthened by ten years' practical experience, at present employed, desires to change. Thoroughly acquainted with manufacturing, maintenance of plant, management and production; expert in handling men; age 36; highest references. Box 184, AMERICAN MACHINIST.

OREGON

Master mechanic, responsible, live man; 20 years' experience in construction and manufacturing in the States, Canada and South America, successfully producing high-grade work at lowest cost. Box 720, St. Johns, Oregon.

PENNSYLVANIA

Draftsman, college graduate, experienced; A-1 reference. Box 198, AMERICAN MACH.

Mechanical superintendent or shop manager; four years' practical experience in pattern, foundry, forge and machine shop work; three years' superintendent of construction work, one year as mechanical draftsman; young active mechanic; college man. Box 186, AMERICAN MACHINIST.

Superintendent with established reputation for getting maximum production, at minimum costs, would like to consider a change; good reasons given. At present successfully engaged as superintendent of well known concern, manufacturing most intricate and highest quality product, where interchangeability is absolutely necessary; 39 years of age; an American, and a hustler; wide experience in factory organization and piece work systems. Box 195, AMERICAN MACHINIST.

Help Wanted

Classification indicates present address of advertiser, nothing else.

ILLINOIS

Wanted at once: Master mechanic and millwright who can take charge of the tool room and repair shop as well as the machinery of a bridge works in Chicago. Some knowledge of electrical work preferred; state age, if married and give references. Wages according to experience and fitness for position. Box 187, AMERICAN MACHINIST.

MASSACHUSETTS

Wanted—A designing engineer familiar with modern high and medium speed steam engine practice; must be able to show a satisfactory experience and refer to a successful practice on not less than three years with a standard concern. A knowledge of economical manufacturing methods for quantity production desired. Box 102, AM. MACH.

MICHIGAN

Wanted—Good operators on National Acme automatic machines. Will pay good wages to first-class men. Also two or three good Potter & Johnston operators. Cadillac Motor Car Co., Detroit.

We want an assistant factory manager who has had experience in the production of the highest quality of cars. This position is worth $4000 or more per year to the right man, as we find good men are by far the cheapest. Applications will be considered only from men of high standing and wide experience in the building of high-grade automobiles. Address R. D. Chapin, General Manager., or J. J. Brady, Factory Manager, Chalmers-Detroit Motor Co., Detroit, Mich.

NEW HAMPSHIRE

Wanted—A young man about 25 years of age with technical training and good experience on machine manufacturing, who has had charge of help, to act as assistant in machine shop on small interchangeable work. Good chance for advancement for the right man. Box 163, AMERICAN MACHINIST.

Wanted—A general foreman familiar with modern practice in high and medium speed engine construction; must know how to get best efficiency from up-to-date tools and equipment. Only such applicants will be considered as can show an executive experience of not less than three years with an up-to-date manufacturing company. Familiarity with modern factory systems necessary. Box 101, AMERICAN MACHINIST.

NEW JERSEY

Wanted—A first-class machinist, who has had experience, preferably on high-speed steam engines, and who has either been a working or general foreman. Give references and wages desired. Box 178, AM. M.

Wanted—First-class head draftsman capable of designing modern printing machinery for an established manufacturing concern near New York. Must have knowledge of economical manufacturing methods. Address, giving full particulars, age and salary, "Opportunity," AMERICAN MACHINIST.

Wanted—General foreman not under 30 years, as assistant to superintendent, in a large printing machine factory near New York. Must have good executive ability, thoroughly practical, and up to all modern manufacturing methods. Address, giving full particulars, age and salary. Box 166, AM. M.

NEW YORK

Mechanical engineer to act as master mechanic and designer of special machinery in large manufacturing plant. Box 174, AM. M.

Diemaker; one accustomed to subpress work. Only thoroughly competent men need apply to Mergenthaler Linotype Co., No. 20 Ryerson Street, Brooklyn.

Wanted—First-class salesman, must have established trade among steam users in engineers' and factory supplies in Greater New York and vicinity. Fine position for right man. Box 131, AMERICAN MACHINIST.

Wanted—By manufacturer, thoroughly experienced man to sell hangers, shafting and transmission machinery in New York City and vicinity. Must be capable, energetic. We want the best man in this line of business. Box 130, AMERICAN MACHINIST.

Wanted, at Rochester, N. Y., mechanical draftsman with experience in power transmission, labor-saving devices and general mechanical drafting. State age, technical training, previous employment and salary desired. Address Box 188, AMERICAN MACHINIST.

Wanted—Superintendent or shop manager of long experience in manufacturing small metal specialties. Expert mechanic, must have executive ability, understand shop organization and operate under modern cost system. State experience, references and salary desired. Box 179, AMER. MACHINIST.

Man wanted to take charge of the machines in a machine shop employing about one hundred hands, to increase output, under the general orders of the department foreman; must have broad experience and be a good and aggressive handler of help. Give full particulars. Applications confidential. "Y. W. X.," AMERICAN MACHINIST.

OHIO

Wanted—Two first-class toolmakers, none but good steady men need apply. Box 196, AMERICAN MACHINIST.

We invite written applications from good men in all our departments; give references, age and experience. The Royal Tourist Car Company, E. 72nd St. and L. S. & M. S. Ry., Cleveland, Ohio.

Wanted—Superintendent in large Ohio sheet-metal-working plant; must have thorough knowledge best shop practice and ability to handle men; state age, experience and salary. Box 171, AMERICAN MACHINIST.

PENNSYLVANIA

Designing engineer able to assume responsibility for development of a line of punch presses and machinery for sheet metals; wide experience in this special field essential; we will pay liberal compensation to right man. Applicants please state experience, etc. Box 177, AMERICAN MACHINIST.

WISCONSIN

Wanted—Mechanical draftsman, who was primarily a shop man; must understand the production of intricate and interchangeable parts cheaply and accurately; must be good jig designer and be able to detail practical ideas to the finished product. State age, experience and salary expected. Box 190, AMERICAN MACHINIST.

For Sale

Valuable patent covering simple and improved apparatus for bench molding is for sale. Facilitates rapid and accurate work impossible with present hand methods. Write for particulars. Ezra Estep, Sandwich, Ill.

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The New Mechanical Woodworker

The Universal Head and Table of This Machine Enable All Kinds of Pattern Work and Woodwork in General to Be Handled Readily

SPECIAL CORRESPONDENCE

The accompanying engravings illustrate a woodworking machine containing many novel and interesting features. The universal range of movements comprised in this machine renders it particularly applicable to the ever varying intricacies of pattern work, and indeed, enable almost every conceivable operation in woodwork to be rapidly and economically carried out. It is an acknowledged fact that though an operator quickly grasps the general working of the machine, it is a matter of time for him to realize to the fullest extent the operations it can perform, since it is only as extraordinary shapes are brought to him that he gradually sees that the flexibility of the machine renders its range of operations practically unlimited. Some idea of the variety of work to which it is adapted may be gathered from Figs. 1 and 2 and from the general views showing numerous operations under way.

The new mechanical woodworker consists broadly of two parts, the machine proper and the table which, with their universal movements form together a complete machine having simple minor adjustments which, as indicated above, can be used effectively on a variety of work such as heretofore has required for its accomplishment a number of independent machines adapted only to separate and individual operations. On account of its sensitive balance and adjustment, combined with its rigid and powerful construction, it is capable of dealing with the delicate and intricate pattern work obtaining in some shops, and with the larger and heavier work of other shops, with equal success. The movements all being simple, it is readily manipulated by the workman and its special feature is that it is at once both a special machine and a common machine, as circumstances and convenience demand, and capable of at once completely finishing work which ordinarily would require rehandling many times over.

The range of the machine allows of a vertical hight of 27 inches from the top of the table to the cutter spindle when the overhanging arm is in its highest position, and the distance between the center of the spindle and the standard is long and provides for meeting all practical requirements.

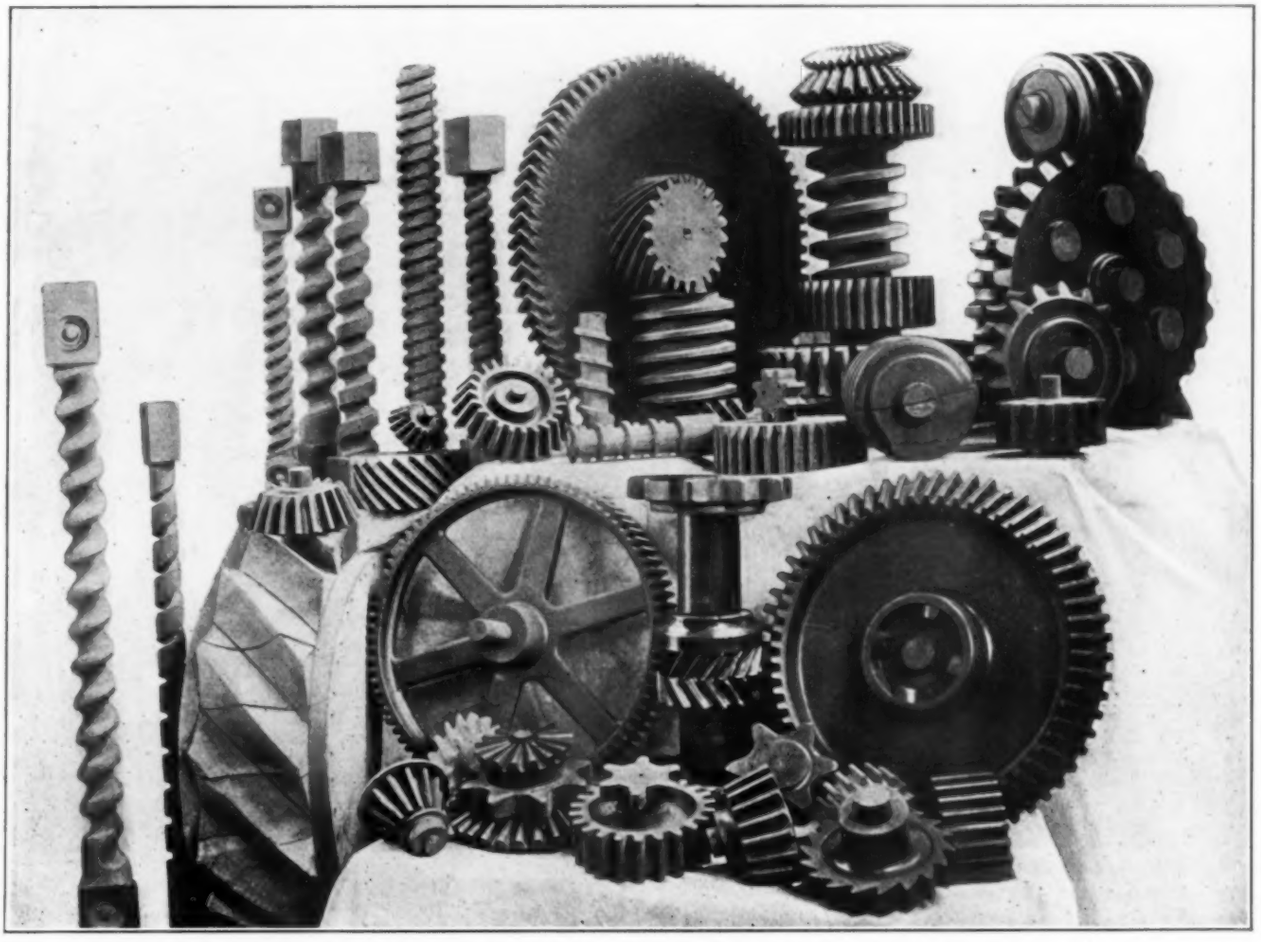


FIG. 1. GEAR PATTERNS AND OTHER PARTS MADE ON THE MECHANICAL WOOD WORKER

The Spindle Drive

The drive in all cases is a variable speed with reverse, and may be either direct by motor carried on the back of the machine, the motor spindle driving direct onto the cutter spindle, or intermediate by reversible and variable-speed motor driving onto the back shaft of the machine from any convenient position; or belt-drive direct through a variable-speed auxiliary countershaft. As will be seen by Figs. 3 and 4, in the case of the motor-

driven machine the switchboard is fixed in a very convenient position, the starting, reversing and regulating switches being well within the reach and control of the operator. In the case of the belt-driven machine, which is shown at the right in Fig. 3, the drive is controlled from the head of the machine by the levers seen in that illustration. While operating in either vertical, horizontal, or any intermediate angular position, the spindle speed can be varied within a range of from 1250 to 3600 revolutions per minute and the direction of rotation reversed instantaneously. The cutter spindle is driven by belt through the head of the machine direct from the back shaft and the highest spindle speed is attainable without vibration of the head and quite noiselessly, the machine being entirely free from gears. The cutter spindle has free-feed movements independent of any movement of the head, either by a quick-acting lever or by a sensitive feed screw for fine adjustments. The slow feeds are capable of such fine regulation that a thin pencil or gage line can be cut in two, which is fine enough for even the most particular of pattern work.

The Table Movements

The table body or base is free to be moved bodily upon its foundation frame on ways and is conveniently actuated by a hand wheel. The table body can be instantly moved across the front of the machine from under the cutter spindle and away sideways altogether clear of the machine head, and when in this position the rocking arm with the spindle head may be rapidly tilted, bringing the spindle into any required relationship with, or below the level of, the table top. In addition to the lateral movement of the table body the table is provided with independent longitudinal and cross-motions. The table may be moved upon sensitive ball races by a feed screw actuated by a hand wheel at the front of the machine, which screw may be thrown out of gear when required, leaving the table free to be easily fed or floated by hand over the ball races, while a right-angle motion is imparted by a rack and pinion also actuated by a hand wheel in front of the machine. The table in addition to having a considerable vertical adjustment, can be turned in a horizontal plane through a complete circle, thus combining rapid right-angle, longitudinal cross- and circular movements, whereby it is enabled to move circularly, lengthways, crossways, or even at any angle relative to the spindle at the will of the operator; the whole series of table movements being provided with quick, adjustable stops.

The Rocking Arm and Head

The rocking arm carrying the spindle head is sensitively balanced on the trunnions so that little power is required to raise or lower it to any required position. This sensitive balance allows of the manipulation of difficult irregular-curved face work, a slight pressure of the hand only on the head of the machine being sufficient to cause it to follow any required form clamped to the machine table; the work being fed past the cutter by the screw, and the cutter spindle rising and falling over the form clamped down on the table top, thus enabling core boxes and other work with curves and shapes of a compound nature to be easily manipulated. The rocking arm is generally operated in a horizontal plane and spring-controlled means actuated from the head of the machine are provided to lock it in such posi-

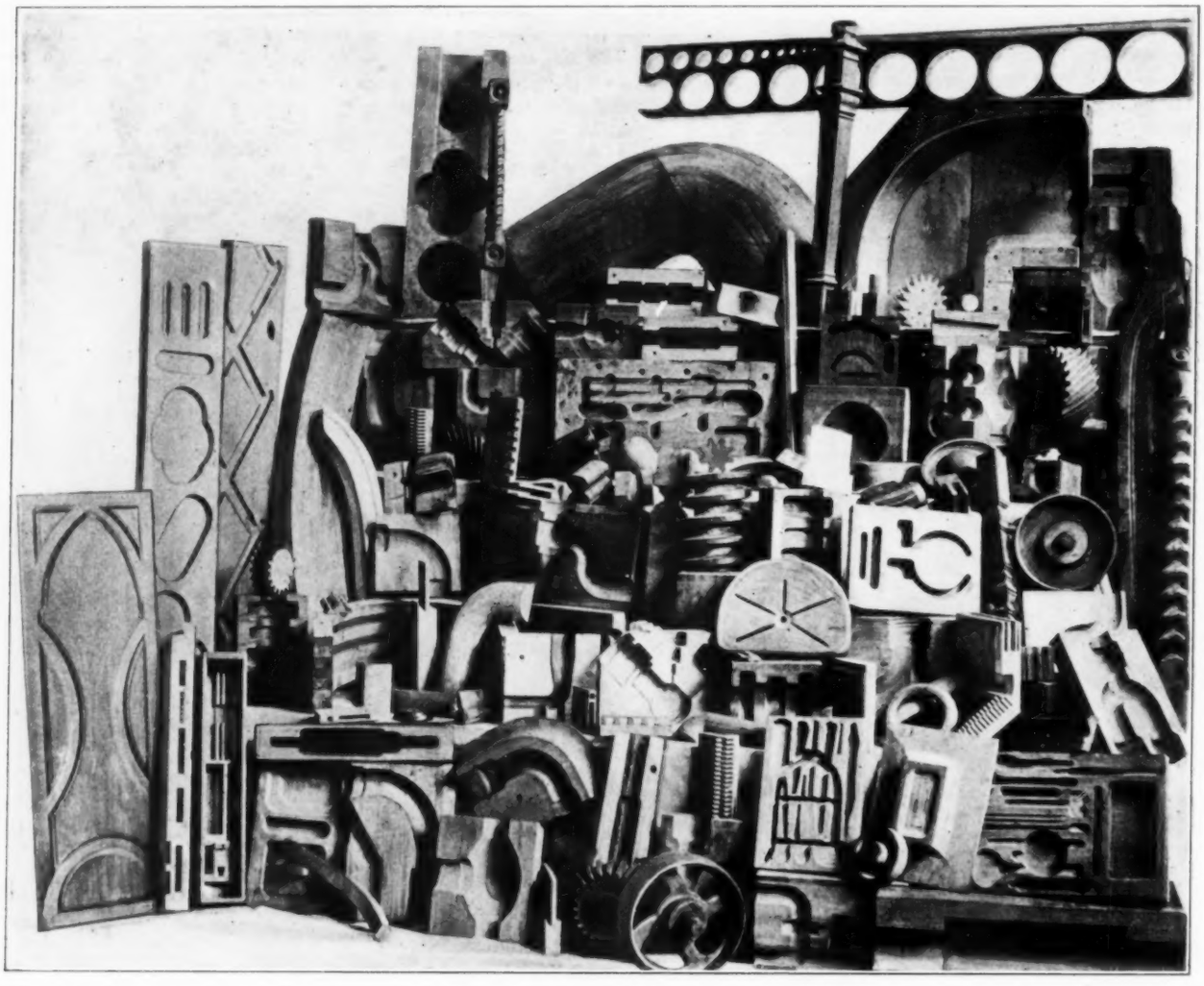


FIG. 2. PATTERNS AND CORE BOXES MADE ON THE MECHANICAL WOOD WORKER

tion, but it can also be locked in any other position required by means of conveniently placed clamping mechanism.

The spindle head is revolvable at the end of the rocking arm and suitable means are provided to maintain it in any desired position. In addition to the quick, positive, self-locking lever feed and the sensitive screw feed of the spindle, the latter may be adjusted to suit the various positions of the feed lever, thereby allowing the spindle chuck to be always worked close up to the bearing. Any subdivision within the full throw of the crank of the lever feed can be effected and any depth of cut quickly arranged, enabling the operator to take a lesser cut in a lateral direction than that provided for by the full lever or crank motion. Changes from one position to another are quickly made and the maximum and fine sensitive adjustments are also instantly available in any direction. All the parts which require manipulation in the working of the machine are so arranged around its head as to be within the reach of the workman while engaged upon any operation.

It will be noticed that in pattern and wood-working shops this machine takes a parallel place with the universal milling machine in metal work, but goes still farther, namely, in the canting of the spindle head, the wide range of vertical adjustment of the latter by the elevation and depression of the rocking arm and by the much greater range of adjustments of the body. By gearing any suitable spiral dividing head with the lead screw of the machine table any wood gear pattern can be cut, similarly to the way metal gears are cut, but, of course, at a rate of speed beyond all comparison with the speed of a milling machine. It is not feasible in this article to give a description of every operation upon which the machine can be employed, the intention being rather to convey a good, general idea of it and of some of the more common operations required in a general engineering pattern, or other woodworking shop.

Points in Construction

The cutter spindle is a steel forging hardened at the chuck end and ground throughout to gage, the two guide rods also being ground to gage. Moreover, the housings of the spindle bearings are ground both internally and externally and the crank, crank pin and die are also ground, the latter having been previously hardened. The top of the main table is ground and tested for truth before being scraped to fit on the slides. The grooves for the balls in the carriage frame are exactly spaced to correspond with the grooves in the tray frame, and the carriage is moreover carefully tested to prove that it has not sprung during machining. The last operation in the fitting up of the machine is the testing, marking and setting of the points by which the correct centering of the table body relative to the spindle may be accomplished. The object of such centering is to place the center of the table-body frame *B*, Fig. 5, in true vertical alinement with the center of the spindle *A* when vertical. To this end the rocking arm *C* is first set in the dead horizontal position in which it is instantaneously locked by the automatic action of a spring-controlled plunger, and it is also held by means of the clamping device provided to secure the rocking arm in any position in which it is placed. The table-body frame *B* (which is ground internally to receive the externally ground barrel of the tray frame) is then traversed by the handwheel *M* to move the center of the circular plate *N* in the table top *D* under the centering tool *O* fixed in the chuck *P* of the spindle. The table, together with the tray frame and carriage, are then slowly revolved in the frame *B*, and the table top *D* is adjusted lengthwise and crosswise until, while revolving the above parts it is seen that the center of the plate *N* remains in alinement with the centering tool *O*. When this is accomplished, an arrow *F* is marked on the edge of the table *D* in vertical alinement with a pointer *G* and an arrow *K* is marked on the carriage exactly over a line *L* on the tray frame *J*. Two conical recesses at an angle of 90 degrees are drilled in the table-body frame *B* so that by means of a clamp plate and screw on the table body, correct right-angle positions of the table *D* may be assured. These features allow

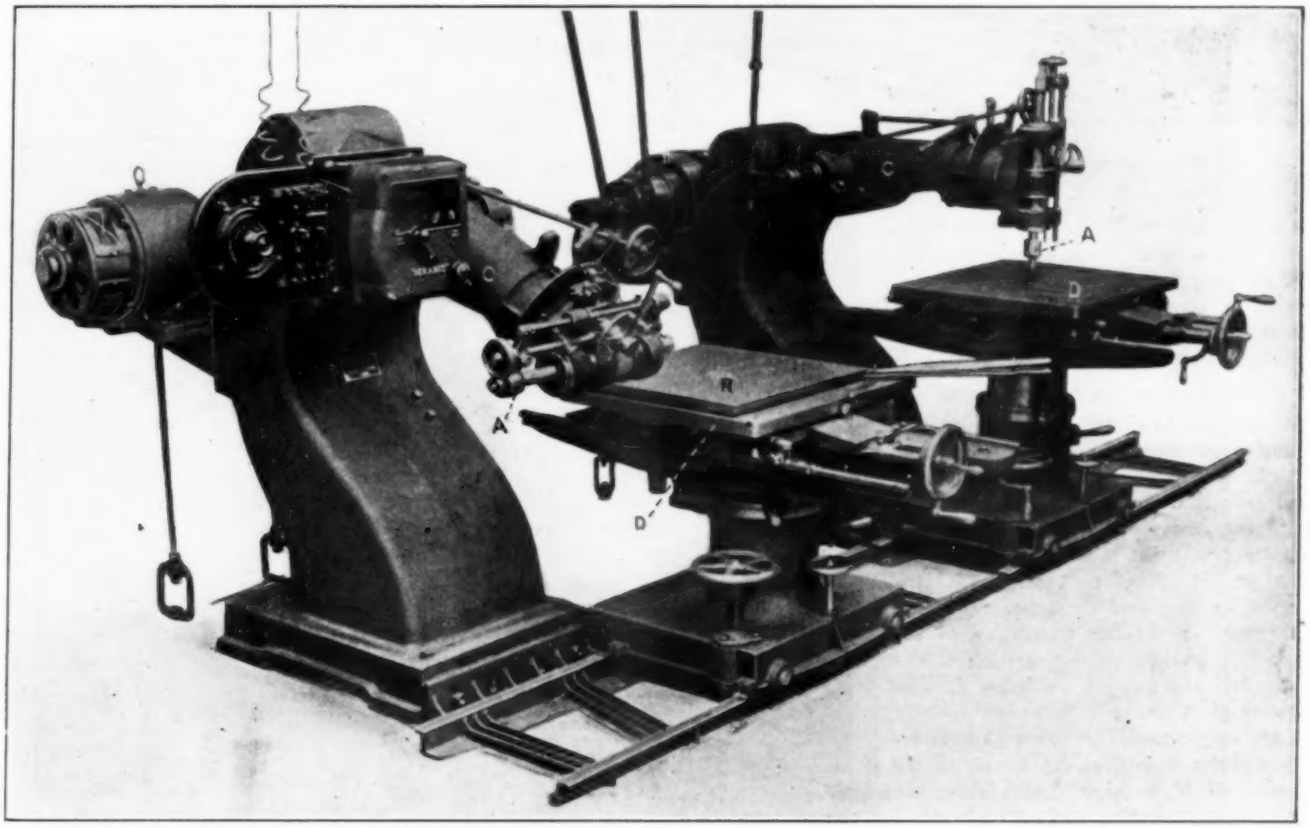


FIG. 3. MECHANICAL WOOD WORKER WITH MOTOR AND BELT DRIVES

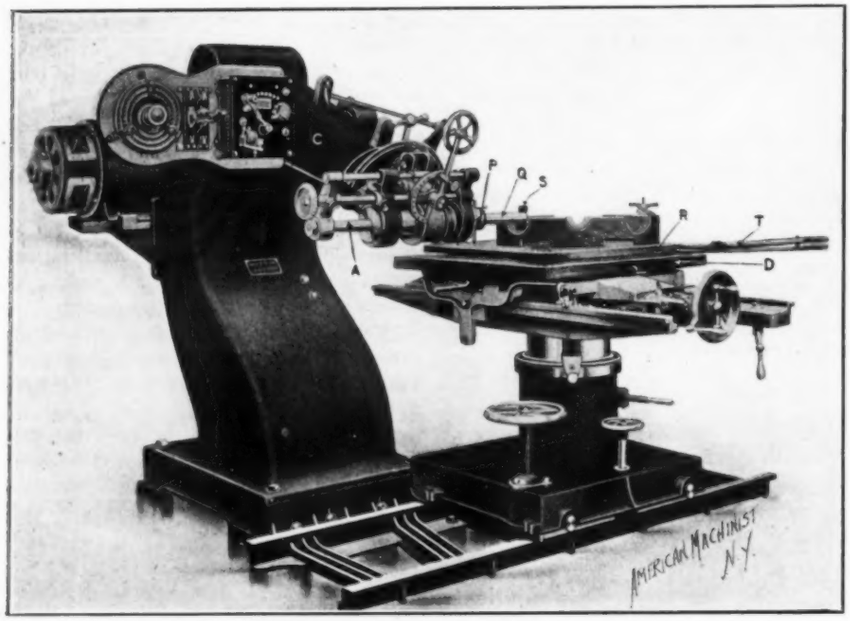


FIG. 4. MOTOR-DRIVEN MACHINE SET FOR CUTTING A 3-WAY VALVE CORE BOX

of an operator readily centering the table body and spindle which is necessary for the carrying out of many operations, and which is accomplished very quickly, no matter in what position the several parts of the machine may be at the time.

Operation of Table and Spindle

In practice, to center the table body and spindle, the operator turns the handwheel *E*, which, through the medium of a pinion and rack, moves the table top *D* laterally until the arrow *F*, marked on the table, coincides with the pointer *G* fixed in the carriage *H*. Next the carriage is traversed by means of the screw feed over ball races on the tray frame *J* until the arrow *K* marked on the carriage is exactly over the mark *L* on frame *J*. The several parts are then locked in position by the simple means provided. The table-body frame *B* is then, by means of the handwheel *M* traversed bodily along the ways until the center of the circular plate *N* in the table top *D* is carried under the centering tool *O*.

The illustration, Fig. 3, shows two machines, one motor- and one belt-driven, under test. It also serves to indicate the capacity and range of movements of the machine. It will be noticed that the farther or belt-driven machine is shown centered as previously described, also that the rocking arm *C* is locked in a horizontal position, and the spindle, barrel of table body and table are all locked in vertical alinement, the table being partly raised. In this view the motor-driven machine is shown with the rocking arm *C* swung down to a level that leaves the cutter spindle just above the level of the table top. The spindle *A* is in the horizontal position and the table *D* is shown lowered and has been moved to the right of the machine.

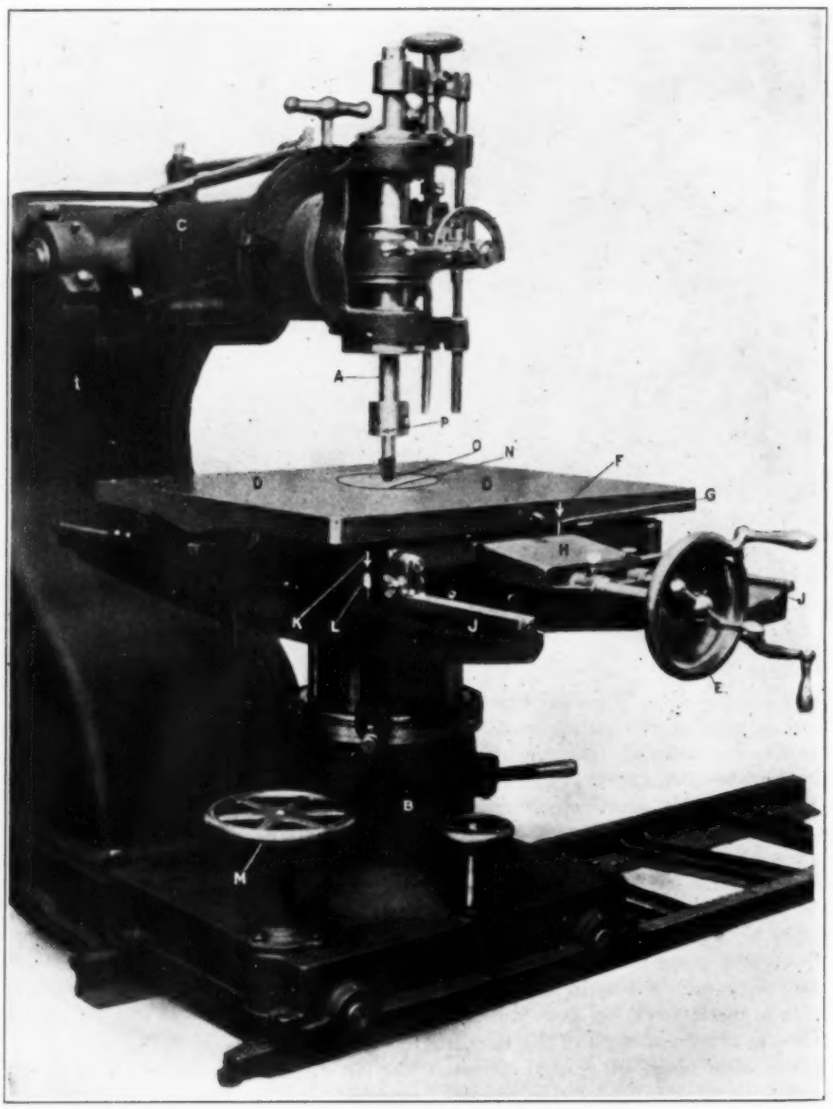


FIG. 5. METHOD OF CENTERING TABLE

Though the spindle is more generally worked in either the vertical or horizontal position, it can be operated equally well at any intermediate angle with the rocking arm *C* tilted to any angle, as in Fig. 6, or with the rocking arm in a horizontal position. Thus a position of the spindle is attainable that renders the machine capable of operations which otherwise could only be accomplished by a canting of the table or by packing up the work.

The Auxiliary Table

Operations combining small radius work are very readily carried out by means of an auxiliary table *R*, which is shown mounted on the table *D* of the motor-driven machine, Figs. 3 and 4. This auxiliary table is primarily provided for small work and is particularly adapted for core boxes and bends up to a radius of 18 inches. It is trued up on its under side, finished square, ground on the face and polished. It is pivoted to the main table

and is graduated along two sides with parallel lines at right angles to the pivot. By the aid of these lines the operator, when working on bends or other radius work is able at once, by placing it over the corresponding lines on the table, to clamp it in the exact position required. This table is controlled and manipulated by a hand lever having a spring plunger adapted to engage in one of a series of holes provided in the table *D* for determining the arc of bend or segment to be cut. To fix the work on the table it is first necessary to locate the center from which the bend desired to be cut is struck over the center of the pivot in the table. This is done by carrying a pair of right-angle lines through the center from the face of the work down to the corresponding lines on the table, then placing the centering spindle *O* in the chuck of the machine and measuring off the radius required, either in accordance with the setting out of the work or the index lines on the table.

Core-box Work

Core boxes of almost every conceivable form and variety can be made on the machine, some forms complete and others so nearly so as to need but little hand labor to finish. Chamberings of almost any section or radius can readily be cut, also bends of all kinds, obtuse, return, compound, or at any angle with sockets or recessings. A number of the views in this article show the machine operating on various forms and in Fig. 2 is included a large number of core boxes which have been cut on the machine. Generally speaking, the cutters employed are simply shaped from flat bar steel and are carried in suitable cutter holders fixed in the chuck of the spindle. The cutters may be of various forms adapted to cut semi-circular, square section, round corners, or any other shapes desired. These simple cutters may easily be made reversible, that is, they may be adapted to cut either way of the grain, and by their use, coupled with the reverse movement of the spindle, the cut can always be taken with the grain of the wood, thus insuring the best possible finish. True semi-circular chambers

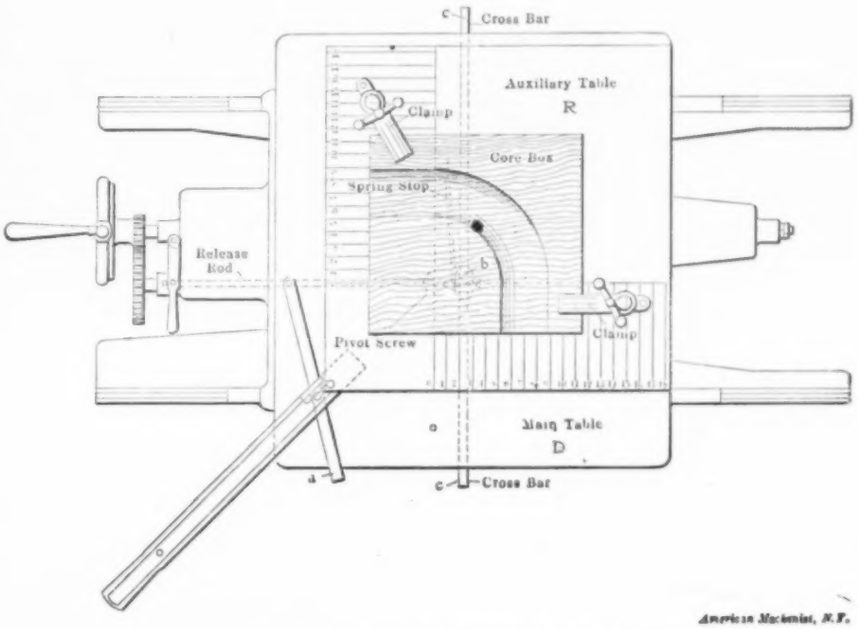


FIG. 7. CORE BOX ON AUXILIARY TABLE

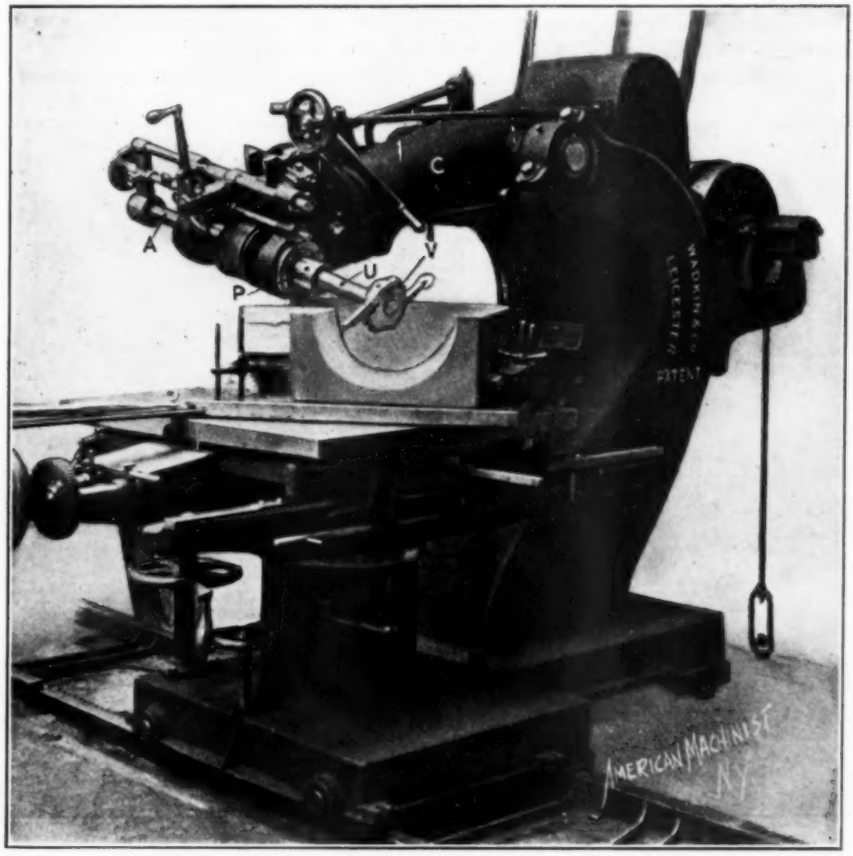


FIG. 6. CUTTING A CORE-BOX BEND WITH THE HEAD TILTED

can be cut into the solid block with dead square stop, or semi-spherical ends and irregular-formed core boxes, globe valves, bell shapes, cones, etc., can all be produced. It is advisable in some cases and to insure greater rapidity, to provide a light former board of the correct contour when very irregular shapes are required. This applies more particularly to the larger class of work.

Cutting a Three-way Valve Core Box

The halftone, Fig. 4, shows the method of cutting a three-way valve core box with internal chambers. The rocking arm *C* is depressed and the spindle *A* placed in the horizontal position. An auxiliary spindle or cutter holder *Q* is fixed in the chuck *P*, and a fly cutter *S* of suitable size and shape for the operation, is fixed in the holder. It may be noted here that each fly cutter will complete a whole range of chambers that may come within its limits. For instance, a 2½-inch cutter will cut a chamber of minimum section of 2½ inches and any length required within the limit of traverse of the table, and by extending the cutter through the slotted spindle in which it is used, chambers of any intermediate size up to a limit of about 4 inches may be cut. The next step after adjusting the cutter to the correct radius is to cut the three converging channels to the smallest required diame-

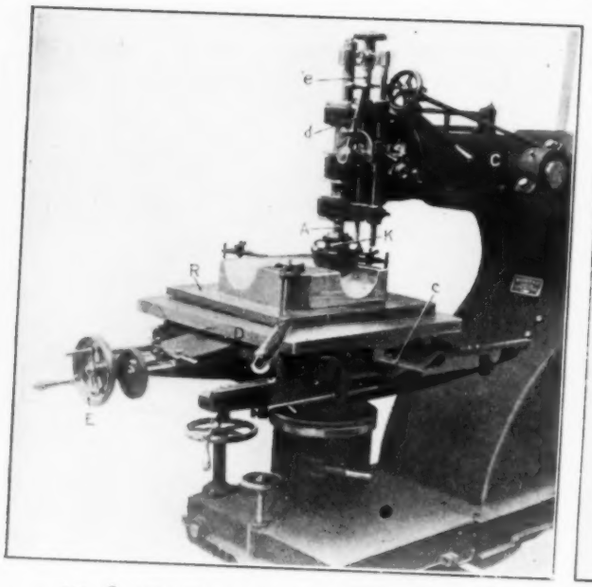


FIG. 8. CUTTING A CORE BOX OF SMALL RADIUS

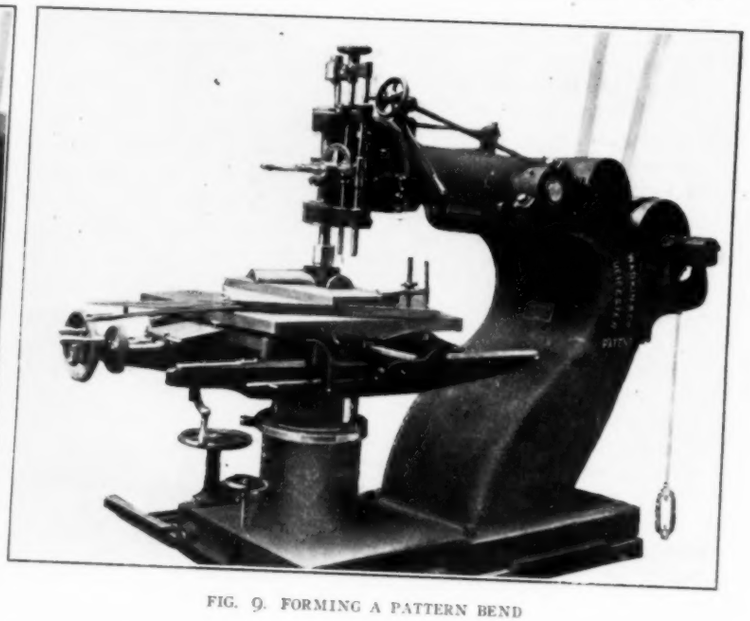


FIG. 9. FORMING A PATTERN BEND

ter, feeding the table carrying the work up to the cutter, the correctness of the semi-spherical cut being insured by the use of a square. When this has been done a depth gage supplied with the machine is adjusted to restrict all the vertical movements of the table, when the work is afterward fed to the cutter in forming the further internal chambers or sockets in the pattern, and to insure all the chambers, etc., being perfectly concentric one with the other. The work is then next slightly lowered from the cutter, and the latter is adjusted to give the next greater diameter of cut required, or another cutter substituted for any special form of chamber to be cut. The table is then raised to carry the work up to the cutters and the above operation repeated, always controlled by the depth gage until all the necessary chambers or sockets are cut in the three converging channels.

When operating on core-box work of this nature, i.e., with various channels radiating from a common center, it is necessary always to begin with the table *D* square in relation to the table body frame, the auxiliary table *R* being pivoted to the table *D* as before described, its position square with the main table being determined by the spring plunger on the lever *T* entering a hole provided in the table *D*. Thus a square position relative to the spindle is obtained and core boxes having any required number of channels radiating from one common center with chambers or sockets in any or all of the channels may be readily and accurately worked, the main table being drilled to receive the plunger of the auxiliary table lever at various standard angles. Any intermediate angles, however, may be obtained and controlled by means of an extension rod *a*, Fig. 7, passing through the auxiliary table arm, with a plunger pin on the under side adapted to engage in the holes referred to in the main table.

Core boxes up to 7 inches in diameter

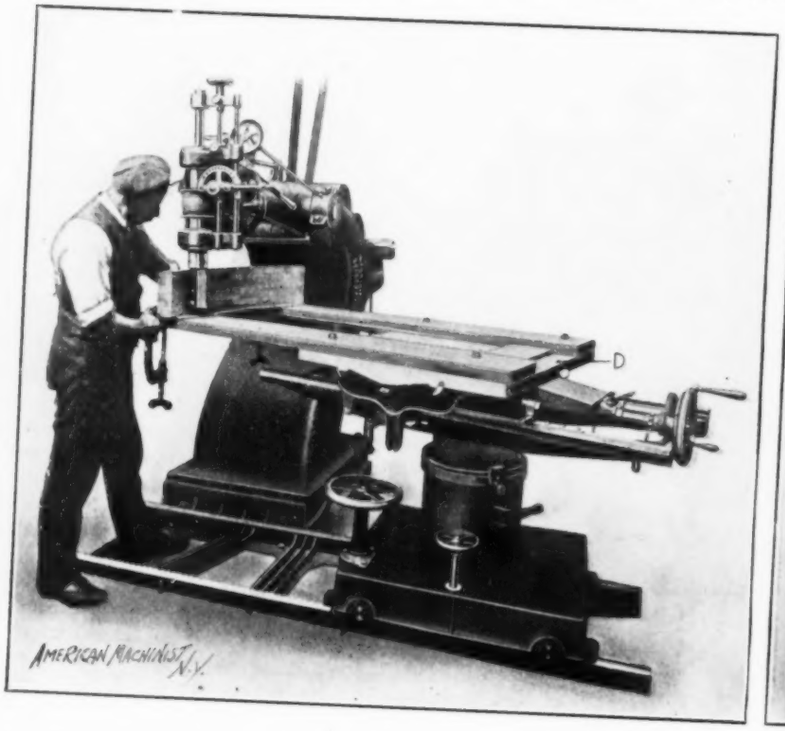


FIG. 10

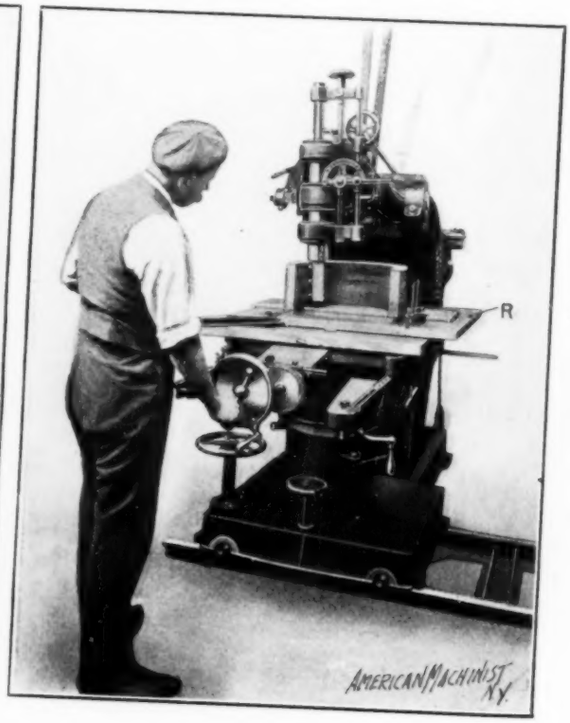


FIG. 11

HANDLING SECTIONAL RADIUS WORK

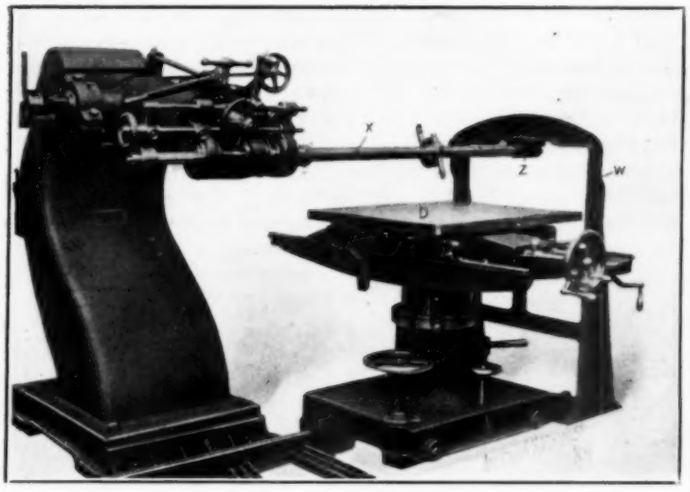


FIG. 12. EQUIPMENT FOR LONG WORK

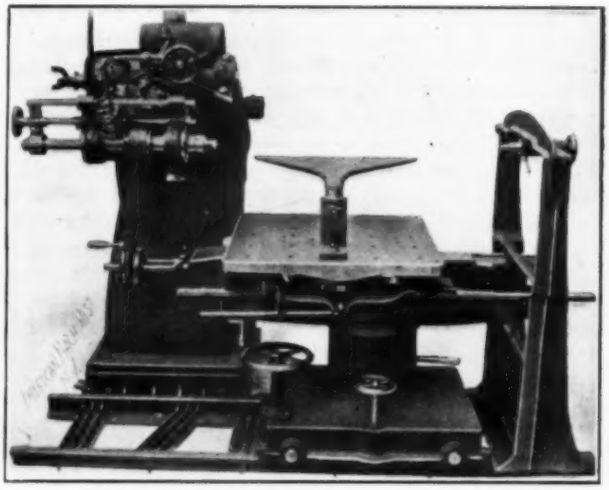


FIG. 13. EQUIPMENT FOR TURNING

can be, and are generally worked with the spindle in a vertical position, the feed being a downward one by lever and sensitive screw, but those beyond that limit and up to 26 inches in diameter are worked with the spindle in the horizontal position, the feed being upward by the raising of the table. Core boxes of all sizes and regular and irregular-shaped bends may be cut without any limit as to radius, depth of chamber, or length of straight parts. The manner of operation and the cutters used necessarily vary, according to the work to be done. For long work of this kind an extension support for the outer end of the cutter bar is provided, which may be attached to the head of the machine.

Small Core Box and Pattern Bends

When operating on small section core boxes and pattern bends of small radius as in Figs. 7 and 8, the rocking arm *C* is set horizontal with the spindle *A* vertical, and a cutter of the semi-circular type used. For all small-radius work having any length of straight at either or both ends of the curve an adjustable cross stop *b* is used, which is mounted on a bar *c* carried on the under side of the table *D*, and adapted to be engaged by a spring-controlled rod, which is manipulated by means of a lever at the front of the machine. This stop automatically arrests the feed of the table at the junction of the straight and the bend, as shown in the line illustration, Fig. 7. Figs. 7 and 8 show a core box with two straight parts disposed at right angles, though any length of straight at the end of any bend or curve, and any angle and variations of this pattern may be cut readily. In this operation, as in working pattern bends of small radius the auxiliary table *R* is used. This is centered with its pivot under the cutter spindle, as previously described. The adjustable cross stop *b*, Fig. 7, is then set with the spring-controlled rod

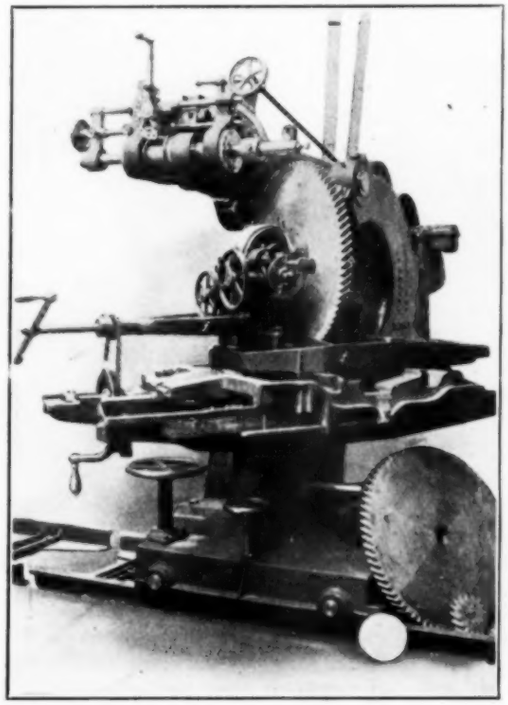


FIG. 14. CUTTING A HELICAL GEAR PATTERN

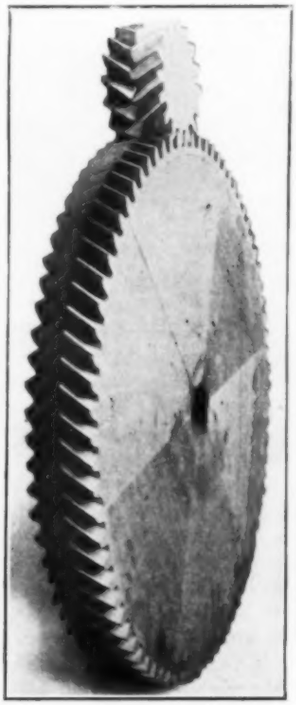


FIG. 15. DOUBLE HELICAL GEAR AND PINION PATTERNS. (GEAR 26½ INCHES DIAMETER)

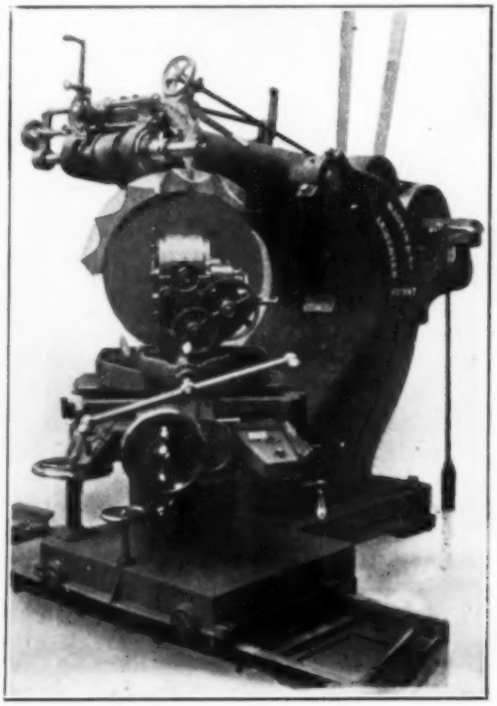


FIG. 16. CUTTING A PECULIAR ROLL PATTERN

in engagement and in alinement with the junction of the straight and the bend. The work is set on the auxiliary table to the required radius as previously noted (the square lines from which the radius is struck being carried down to the corresponding lines on the table *R*) and then fixed in position and held by the quick-acting adjustable clamps plainly seen in

is then fed down by lever *d* a suitable distance for the first cut. The machine is then started and the table is fed sideways by the handwheel *E*, the cutter traversing along the straight portion until the spring-controlled rod engages the stop indicating the commencement of the bend. The auxiliary table *R* is then turned around on its pivot to an angle of 90 de-

operation of setting the machine from an inactive position to the completion of the core box shown, occupying not more than 8 minutes. The operation of cutting a bend pattern, as in Fig. 9, is similar with the exception that the work is screwed to a board which is then clamped to the auxiliary table *R*, the bend being cut first at one side and then the other at two

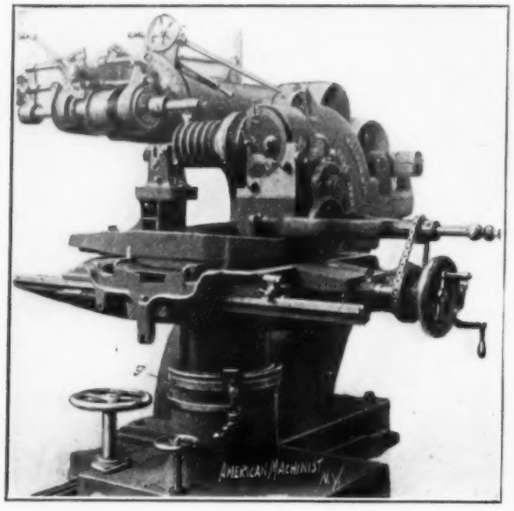


FIG. 17. CUTTING A WORM PATTERN

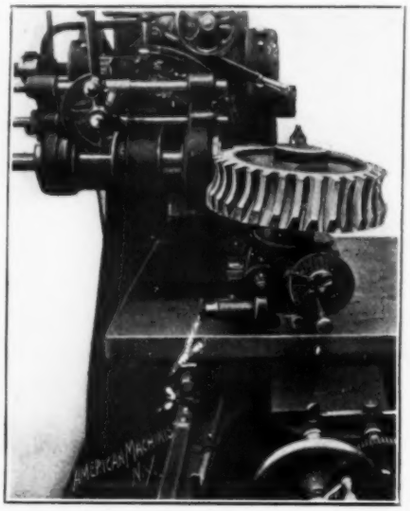


FIG. 18. CUTTING A WORM-WHEEL PATTERN

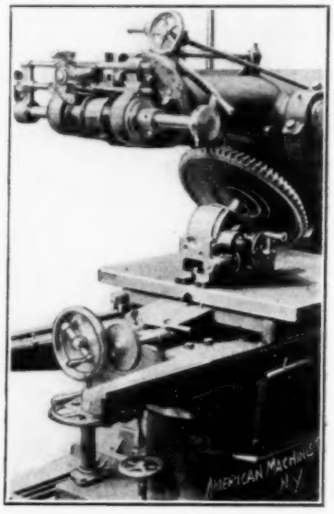


FIG. 19. CUTTING A BEVEL-GEAR PATTERN

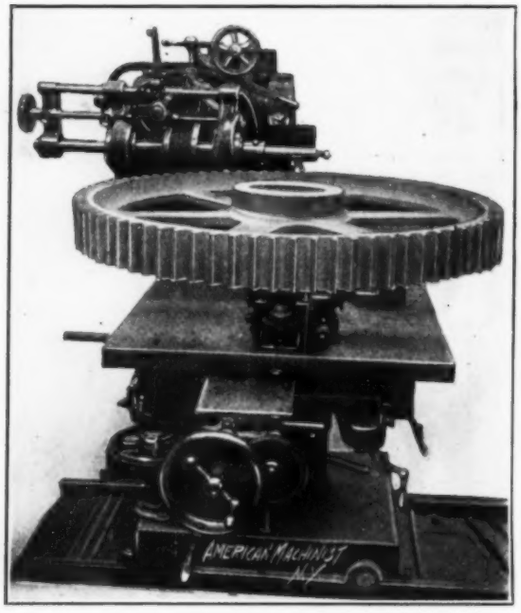


FIG. 20. CUTTING A LARGE SPUR-GEAR PATTERN

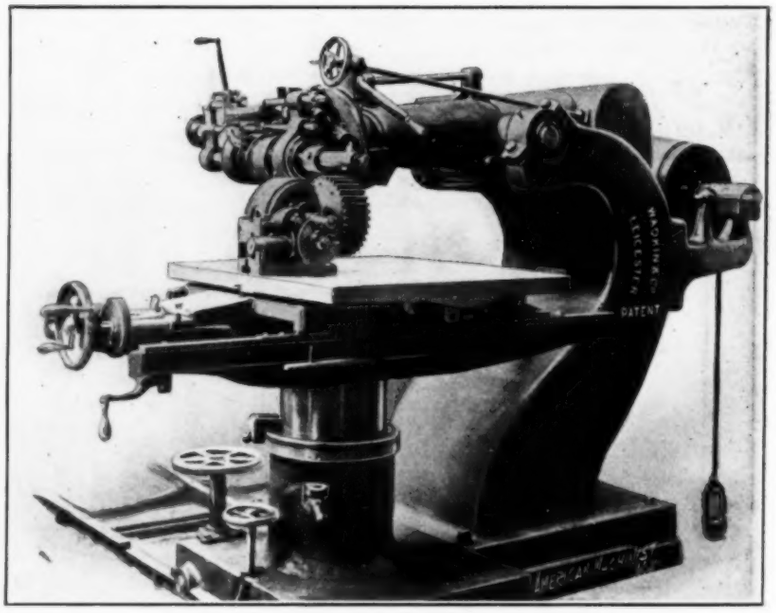


FIG. 21. CUTTING A SMALL SPUR-GEAR PATTERN

the illustrations, Figs. 7 and 8. It should be here noted that where the cutter is to be fed into the work by the lever feed on the spindle, the chuck *K* in the cutter holder should always be drawn close up to the bearing to allow of the limit of downward feed being obtained. Before commencing the cut the table is raised until the face of the work just clears the cutter; it is then moved sideways until the end of the pattern clears the cutter, which

grees, the spring-controlled plunger pin in the handle then engaging the index hole in the table top *D*. The spring-controlled rod is then withdrawn and the table is fed sideways along the straight at right angles to the first cut. This operation is repeated, the cutter being fed down by the lever in the second cut to within a fraction of the finished size. A very fine finishing cut fed by the sensitive screw *e* is then taken; the whole

separate operations by a cutter of the shape shown.

Large Core-box Bends of Small Radius

When operating on large section core-box bends of small radius, such as are shown in Fig. 6, an expanding cutter head *V* is used. This patent head is novel in character and is adjustable for all diameters from 5½ to 14 inches. As shown, it is carried by a spindle *U* fixed in the

chuck *P* and consists of a forged block *V*, through which are passed adjustable rods carrying the cutters. Two pairs of rods are provided with each head, one pair expanding from 5½ to 8½ inches, the other from 8½ to 14½ inches. Various shapes and forms of cutters, cramped or otherwise, may be used. Any length of straight can be cut by using the ordinary movements of the table to feed the work to the cutter. In this operation, Fig. 6, the same movements of the table apply as for the smaller work described, but in this case the rocking arm *C* is slightly inclined, and the spindle *A* canted to a slight angle, as shown, to allow of the work being manipulated clear of the head of the machine. To compensate for this canting of the head and to insure a true half circle being cut in the work, when setting, the table is slightly slewed around to bring the head square with the chuck of the machine. For core boxes, chambers, etc., from 14 inches upward to 26 inches in diameter, expanding disk cutters, each expanding 3 inches, that is, 14 inches to 17 inches, 17 to 20 inches, etc., or any size giving an expansion of 3 inches, are used.

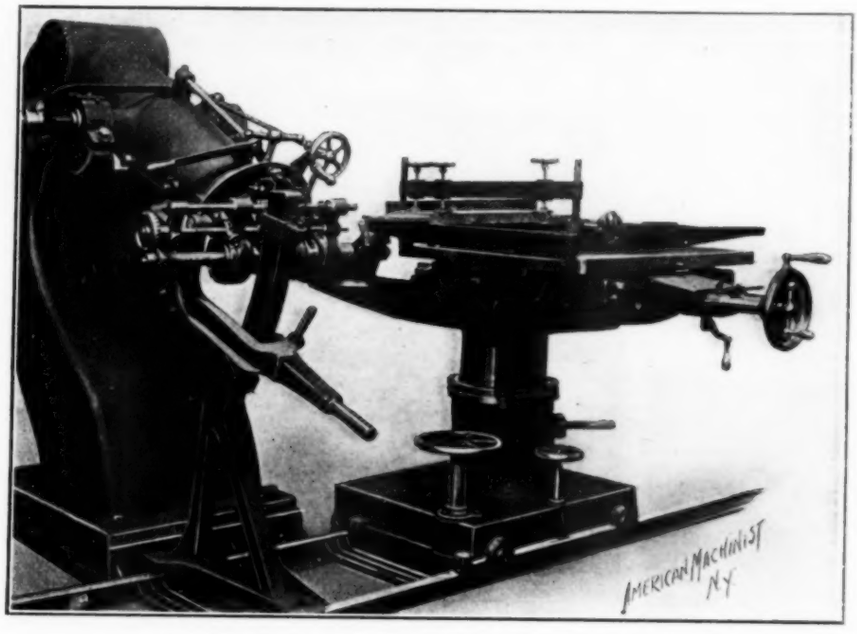


FIG. 22. EQUIPMENT FOR TENONING

Sectional Radius Work

Work like that shown in Figs. 10 and 11, built up of segments straight from the band saw, of any radius and to a depth of 14 inches is readily machined both on the inner and outer surfaces. Sections of any length can be worked and any required taper or "draw" given to the work.

The cutter head used is provided with lips which serve as back irons to the cutters insuring the cross sections of the work being smoothly machined. Generally speaking, in all radius work the spindle operates in the vertical position and it is obvious that the work must be supported and rotated in contact with the cutters, at the correct radius, which is obtained by traversing the part on which the work support is fixed and rotated the necessary distance from the spindle, due allowance being made for the cutters. Operations of small radius, as in Fig. 11, are conveniently carried out by using the auxiliary table, pivoted to the main table, or the work may be fixed to the latter table; and for larger radii up to approximately 4 feet a simple light wood frame clearly seen in Fig. 10 is all that is necessary. For any radius above 4 feet a light wood former cut from thin board is all that is required. The whole or any segment of a circle can be worked and any required straight can be continued at the ends of the curved sections, the larger work requiring temporary support during the operation for that portion overhanging the table.

The illustration, Fig. 10, shows the machine cleaning up on the inside a sweep 7 inches deep to a radius of 4 feet. For a radius of this length the work is fixed to a simple work-supporting frame as shown, screwed to the face of the table *D*, the latter being centered over the barrel of the table body frame as previously described. It should here be explained that the center of the rim or segment is generally taken as the radius; it will be obvious, however, that this is simply a question for the operator, who may set from one or both faces or the center as he may consider best.

To obtain the correct cutting radius first the spindle is tilted to give the desired amount of draw, the table is then centered over the barrel as previously explained and the centering tool *O* being placed in the chuck *P* (see Fig. 3) the table body frame is moved along the foundation ways until the desired radius is reached; it is then locked to the foundation frame and not again moved until the operation is completed, the cut being operated by the rotary movement from the barrel, and the fine setting or amount of cut being regulated by the table screw. After completing the inner face of the work, to operate upon the outer face, all that is necessary is to operate the table screw to bring the work to the opposite side of the cutter, then tilt the head to the correct degree in the opposite direction as defined by the graduations on the head of the machine and operate past the cutter as before, the exact adjustment of cut being obtained by the leading screw of the table. The cutter shown operates at one cut on work to a depth of 7 inches. For a greater depth of work the cut is repeated.

The view in Fig. 11 shows the machine operating on sectional work to a radius of 9 inches only, the auxiliary table *R* being used. It may here be explained that on account of its easy manipulation the auxiliary table is preferred for all radii up to about 18 inches. The whole or any segment or section of a circle can be machined, and any length of straight may be worked at either or both ends of any section or segment by using the adjustable stop described in connection with Figs. 7, 8 and 9, and traversing the table *D* to work the straight.

Handling Long Work, Turning, etc.

Fig. 12 illustrates the simple means adopted for operating on large and long work. A large bracket *W* and long cutter or boring bar *X* are shown mounted in position. This bracket may be fixed in any position on the foundation frame to support cutter bars or spindles of the necessary length. Various sizes of cutter bars and cutter heads may be used and channels may be cut and chambers, recesses and the like readily sunk in any position in work of any length and any section within the capacity of the machine. It will be noticed that the bracket *W* is open to permit long work to be passed under the top rail and between the uprights. The bearing *Z* in the bracket is adjustable in its seat to allow of its rapid alinement and is dropped down below the top rail, thus providing ample clearance when a full half circle is being cut in the work. The vertical movement of the table permits any required depth of cut to be taken and the table with work fixed upon it can be actuated by the screw feed backward and forward under the cutter and between the uprights of the bracket as desired. The same bracket is very conveniently utilized when the machine is used as a lathe, for which purpose an adjustable tailstock which fits the bearing in the bracket, a center driver for the spindle chuck, a face plate to fit over the center driver, a hand rest and tool holder and other suitable parts are supplied. A

good, general idea of these parts is conveyed by Fig. 13.

Other suitable parts are provided for square turning, also special attachment with the necessary gears for coupling to the lead screw of the machine for spiral turning. Thus the machine is quickly adapted to perform any turning operation.

Square turning (or shaping square to any design, size or length) is readily effected; this operation being carried out by means of a long cutter block held in the machine spindle at one end and supported in the bracket at the other end. On this block are fixed cutters, of the necessary shapes to produce the pattern required, the work being fixed on the table and slowly traversed past the cutters. A number of pieces of work may be handled side by side at one operation, the table being filled to its full capacity. After working the upper faces, the work is removed and turned round to present fresh faces to the cutters, and so on until all the faces have been finished. The machine is capable of dealing with small, delicate patterns, or work up to a section 18 inches square.

Cutting Gear Patterns

Patterns of gears, either helical, worm, bevel, or spur, are readily cut by means of the spiral head. When about to cut a helical, or worm gear, the table top and table body are truly centered relatively to the spindle as previously described. When this has been done the table *D* is removed and the special frame *f* carrying the spiral dividing head which is geared to the leading screw of the machine, as plainly shown in the illustration, Fig. 14, is substituted. A good idea of the method of cutting a helical wheel may be gathered from this view. To form a complete double helical wheel pattern, the two parts are cut separately and then fixed together. The correct angular position of the table to right or left is obtained by means of a ring *g* fixed on the table body, which is graduated in degrees. This cannot be seen in Fig. 14, but its position is indicated in Fig. 17, which also shows the pointer to which the graduations are set in adjusting the table to the required angle. The double helical wheel and pinion in Fig. 15, which are 26 inches and 5½ inches in diameter, respectively, were cut completely in 1½ hours. Any shape or pitch of tooth may be cut on the machine, and as an illustration in this direction, Fig. 16 is presented, showing a "Krajewski" roll pattern being cut. To carry out this operation, one side of the tooth is first cut, then the cutter and the motion of the spindle are reversed to cut the second side of the tooth. As when cutting the helical gear, the special fixture and spiral head are required. In this, as indeed in cutting all the forms of gear patterns, a simple fly cutter only, shaped from a flat piece of steel, is used.

From this description of spiral gear-cutting operations it will be readily understood that worm and worm-wheel patterns may be easily and quickly produced, the application of a spiral head geared to the machine making it possible to produce patterns of correct form in a few minutes that, if made by hand, under ordinary conditions, would in many instances take several days to cut. It is no exaggeration to say that generally speaking any gear can be cut and completed in considerably less time than it takes to mark it out in readiness for hand-cutting. The worm and worm-wheel patterns shown in Figs. 17 and 18 were respectively cut in 12 and 20 minutes.

Bevel and Spur Gears

In Fig. 19 is clearly shown the simple operation of cutting a bevel wheel, in which operation the gear-cutting attachment is not used. The spindle is placed in horizontal position, the dividing head mounted on the table and the faceplate or other work support carrying the pattern to be cut is canted so as to place the pattern at the required angle or bevel. Two cutters are used in the operation, one giving the correct shape at the back, and the other the correct shape at the front end of the tooth. It is necessary to take three cuts to form the tooth, leaving a very slight projection on both faces near the middle of the tooth, which is quickly cut away by hand. To carry out this operation it is necessary only to set out one or two teeth, the pattern then being cut rapidly.

Figs. 20 and 21 illustrate the methods adopted for cutting spur wheels, which, whether of large or small size, may be cut with facility and with a saving of time in proportion to their size. The teeth of the small wheel, 10 inches diameter and 3 inches face, as shown in Fig. 21, were cut and finished from the solid in 11 minutes. The whole of the 81 teeth of the large wheel, Fig. 20, were cut and finished in considerably less than two hours, each tooth being taken at a single cut with a simple flat fly cutter.

Spur wheels up to 9 feet 6 inches diameter can be cut, those sizes which are too large to be operated in a vertical position being cut horizontally. Bevel and spur wheels may be indexed by any simple dividing appliance, a standard dividing head of necessity not being required. A sheet of instructions for carrying out the operations described is included with the gear-cutting attachment.

Other Operations

The full range of uses of this machine cannot be gaged from the comparatively few examples already given, mostly referring to pattern work only, but may be better judged from the following enumeration of a few of the operations in joinery, cabinet and other work to which the machine readily lends itself, many of which also apply to the work of the pat-

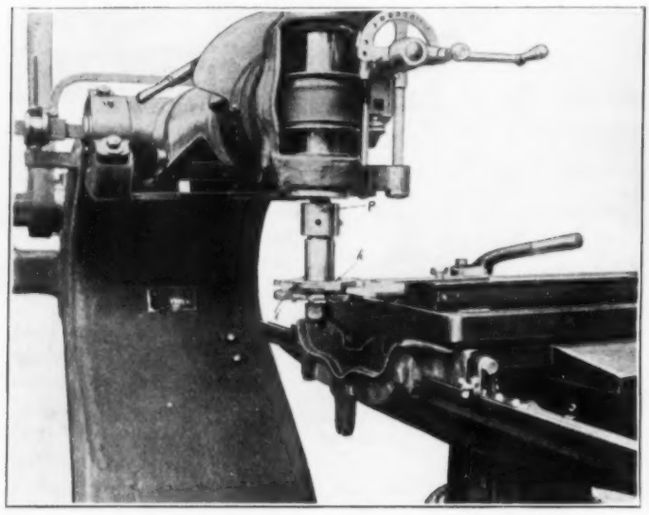


FIG. 23. A TENONING OPERATION

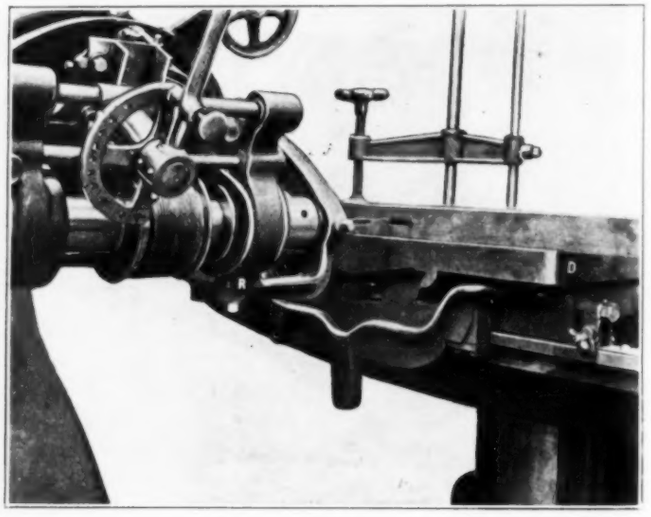


FIG. 24. A MORTISING OPERATION

ternmaker, and particularly so in pattern shops where a limited amount of joinery work is done: Molding, under and over, straight or irregular; cross-grooving, trenching, halving and jointing; recessing and routing; rounding curves; boring and slotting holes at any angle; facing, sinking; molding straight or curved arms of wheels and shaping bosses; recessing and trenching of every variety and description; boring up to 6 inches in diameter, or any larger size by rotating the work table; filleting; cutting dowels; cross-cutting; straight-corner locking, half lapping, jointing, plowing; dovetailing; slot mortising and recessing; square mortising; single and double tenoning and scribing; panel raising and molding to any design, square or irregular; turning spiral and ornamental twists, etc., to any design, size or length; fluting, straight or taper, square, round, oval or any section; tracery pierced and molded out of the solid, and numerous other operations, for which no special attachments are required. Some illustrations are given of one or two of these general woodworking operations; Fig. 22, showing under and over tenoning, this applying particularly to very heavy work, and Fig. 23 illustrating the method of tenoning and scribing at one operation. In the operation shown in Fig. 23, two disk cutters, *h* and *i*, with a spacing collar for regulating the thickness of the tenon are mounted on a cutter spindle, which is fixed in the chuck *P*. The spindle head for this operation is fixed in a vertical position, with the rocking arm horizontal. The work is clamped on the table and abuts against a fence, provided with suitable stops for regulating the length of tenon and distance between shoulders. The feed for the work may be rapidly manipulated by hand or by the table screw.

In the simple method of under and over tenoning, illustrated in Fig. 22, an arc bracket carrying adjustable stops for regulating the thickness of tenon, is fixed on the foundation frame and a radial arm is fixed to the head of the machine for readily raising and lowering it in between the stops deciding the required thickness of tenon. The head of the machine is operated in a horizontal position with the chuck close up to the bearing. The cutter head used is provided with shoulder cutters and is so constructed as to take a decided skiving cut. Very heavy tenoning or halving cuts can be taken if required. On the machine table is fixed a tenoning frame, which is provided with quick adjustable clamps and distancing stops. The work is placed on this frame and can be rapidly fed past the cutter by the screw feed, or preferably by throwing the screw out of gear, and floating the table carrying the tenoning frame over the ball races past the cutters. This admits of rapid manipulation of the work. In tenoning, the top cut is generally taken first, the cutter is then rapidly lowered to the distance stop on the arc bracket by means of the radial arm and the lower cut taken, completing the operation. The distance stops on the tenoning frame are set to give any required distance between shoulders.

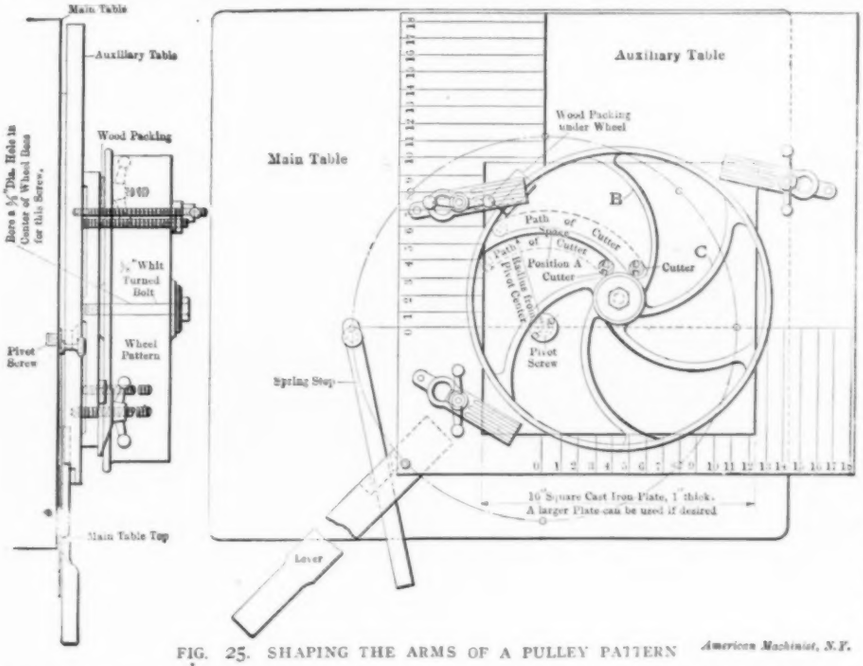


FIG. 25. SHAPING THE ARMS OF A PULLEY PATTERN *American Machinist, N.Y.*

Fig. 24 shows the method of square mortising. For this operation a simple bracket *j* carries the hollow chisel in alinement with the boring bit, carried in the chuck. The work abuts against a fence and is held down on the table *D* by a quick-acting clamp. The chisel is fed into the work by the lateral movement of the table and then withdrawn. To complete the mortise the table is moved lengthwise, the width of the cutter, and the operation is repeated until the desired length of mortise is obtained.

Forming Irregular Work

There are other unique features of considerable advantage, one of which is a special former apparatus for the execution of irregular forms or curvilinear shapes in carrying out which operation the spindle is allowed to float in the head of the machine, the movement being controlled by a former pin which is caused to traverse in contact with the templet or form to be reproduced. Another important operation is the cutting of compound curves for core box or other work. To do this, first two light rough wooden templets are cut to the required curves, one of which is fixed edgewise on the machine table, and the other flat. The trunnion caps are slightly loosened to allow of the head of the machine, which is nicely balanced, being floated or guided over the edgewise templet, the cutter spindle riding over this, the cutter naturally following the correct contour and giving the required curve in elevation. A slight pressure only of the hand on the head of the machine is sufficient to control this. To get the curve in plan the table in this operation is left free to float on the ball races, the movement sideways being controlled by a weight attached to a cord fixed to the table carriage and carried over a small pulley attached to the table body frame, by means of which a pin which is fixed in the head of the machine is kept in contact with the edge of the flat templet giving the required shape in plan. The employment of the weight mentioned to govern the curve on plan allows of the operator having his hands practically free to feed the table on which the work is fixed, past the cutters.

Cutting Pulley Arms

As a final illustration Fig. 25 is presented showing a method of forming the arms of a pulley pattern. As illustrated, the pattern is mounted on a stud secured in a cast-iron plate which is fastened to the auxiliary table. As the table is swung about its pivot, the arm *A* is operated upon by the cutter first on one side and then on the other; then the pulley is indexed to bring arm *B* into the position first occupied by *A* and the second arm finished. The same procedure is followed for each arm, the whole series thus being shaped expeditiously.

With this machine a general equipment and a full range of cutters, mostly of the expanding type, and appliances of various kinds may be supplied to suit any particular class and kind of work to be done. The machine is manufactured by Messrs. Wadkin & Co., of North Evington Engineering Works, Leicester, England, and the Oliver Machinery Company, of Grand Rapids, Michigan, have the sole selling rights for the United States.

Circular Dividing Attachment for the Bench Lathe

By Walter Gribben

My bench lathe, in common with nearly all the other makes, has a row of holes in the belt flange of the cone pulley with which to do circular dividing, or indexing as it is commonly called, but the capabilities of this device were altogether too limited to suit my requirements, so I constructed the apparatus attached to the back end of the lathe head, as shown in the accompanying halftone, Fig. 1, and sketches, Figs. 2 and 3. In general, it consists of a worm wheel *D* in the lathe spindle, a worm shaft *C* standing crosswise of the lathe underneath the worm wheel, a crank *S* with index pin on the front end of the worm shaft, and an index plate *R* for this pin to engage in. Thus far the device is old. The novelty consists in a secondary worm wheel on the edge of *R*, and an index ratchet *X*, this secondary arrangement being the invention of a Canadian gentleman, W. H. Croker, Orillia, Ontario. Mr. Croker's ideas and my own are somewhat different in regard to what is right and proper for the number of teeth in the various members going to make up the complete apparatus, but that does not affect the principle involved, so I will describe my apparatus as I built it, leaving Mr. C. to tell about his conception of the ideal device, should he care to do so.

The back end of the lathe spindle was keyseated by the makers to receive an index plate, so it was a comparatively easy matter to fit on the gray-iron worm wheel *D*, shown dotted in Fig. 2. This worm wheel has a threaded hub in the side toward the spindle bearing and a steel ring nut *h*, Fig. 3, with radial holes for a pin wrench serves to force *D* off the spindle when it is desired to put on the screw-cutting apparatus in its place. Worm wheel *D* has 120 teeth that were cut with a standard 26-pitch spur-gear cutter, the milling-machine table being set around to the helix angle of the worm at its pitch line, and the worm-wheel blank fed directly up against the cutter so as to gash it, the depth of cut being 0.083 inch, the regular depth for 26 pitch. As worm *C* to mesh with this worm wheel was to be cut 8¼ threads per inch, the pitch diameter of the wheel blank was sized for the circular pitch corresponding to 8¼ per inch linear, which is 0.1212 inch, but the diameter addendum of the wheel was made to suit the 26-pitch cutter. As the circular pitch corresponding to 26 diametral pitch is 0.1208 inch, this left the wheel teeth 0.0004 inch thicker than the spaces, but this was compensated for when cutting the worm afterward by making the spaces 0.0004 inch wider than the threads.

The casting *A*, Figs. 2 and 3, is fastened to the back end of the lathe head by two hexagon-head cap screws and two dowel pins. The casting *B* is pivoted to *A* by the shouldered screw *E* at the back, while at the front the shouldered screw *F* is tapped into *B* and the shouldered part goes through an oblong washer under its head, partly shown in the halftone. This arrangement allows *B* and all the parts attached to it, to have a slight rise-and-fall motion around *E* as a center, sufficient in amount to place *C* in or out of mesh with *D*, as may be desired. To put *C* in mesh, the thumb of the right hand is placed on the handle *O*, while the fingers are placed under the handle *M*. By closing the grasp, *C* will rise if the teeth of *D* are in the proper position to receive it, but if they are not, the resistance offered will be felt by the right hand, and the left can then be used to turn *D* slightly, so that its teeth may engage the worm threads. To drop *C* out of mesh the fingers are placed under *M*, the thumb on *N*, and the grasp closed. When the threads of *C* are in mesh with the worm-wheel teeth, the latch *G* is forced over the half-round pin *H* by the spiral spring around the handle *N*, and *B* is thus securely held at the proper hight. *H* is tight in *A*, while *K* is a shouldered screw that serves as a pivot for *G*. The hooked end of G is hardened, as is *H* also. The acting face of *G* was ground after hardening, but not using *K* as a center on which to grind it. The center selected was at *L*, which gave *G* a slight "draw" as it slid over *H*, and the distance *G* can go in this direction is limited by the eccentric *J*, shown in detail in Fig. 7. The shank of *J* is split and slightly spread before pushing into a smooth hole in *B*, so it will remain in any position to which it is turned by a screwdriver applied to the slot in the eccentric head. The piece *I* is pivoted to *B* by a shouldered screw, and hangs down in the position shown when the indexing device is in use, but when the lathe is used for ordinary turning, the piece *I* is turned up a little past a vertical position, when it gravitates toward *H*, and getting under that pin, forms a safety device to prevent *C* from being accidentally raised while the lathe is running.

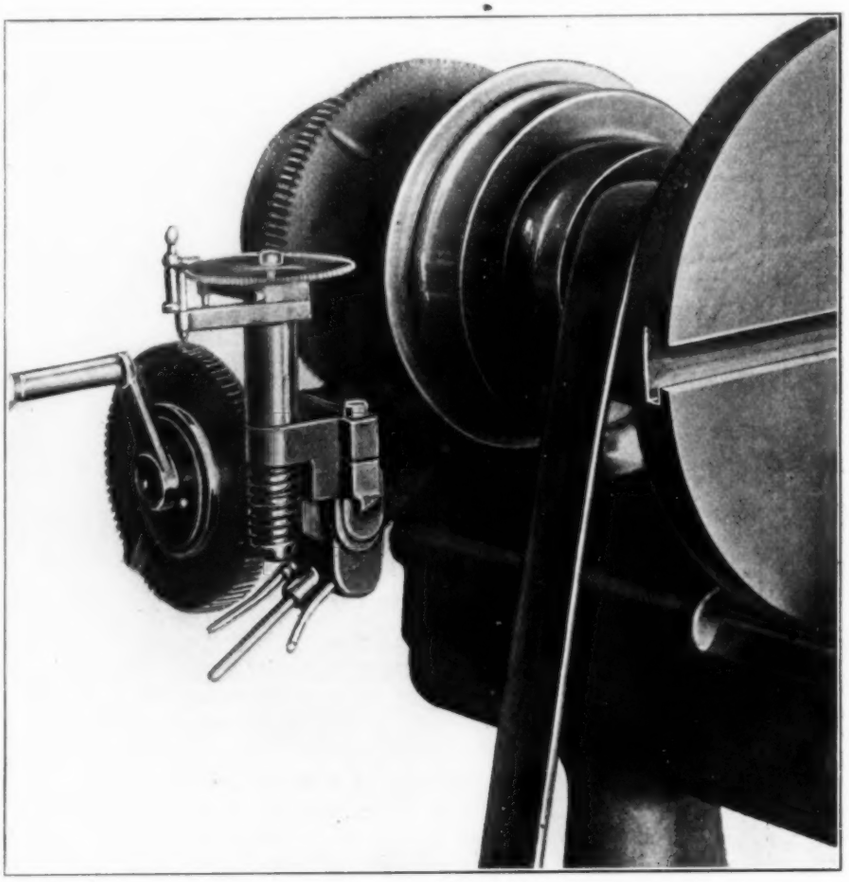


FIG. 1. CIRCULAR DIVIDING ATTACHMENT FOR THE BENCH LATHE

The shaft on which *C* is mounted runs in two bearings cast in one piece with *B*, the back bearing having a straight hole, split on the side to take up the shake, while the front bearing is conical on the side toward the crank *S*, the shaft being drawn into this conical seat by the split nut *P* which is screwed up against the washer *Q* that slides on a spline in the shaft. The crank *S* is screwed and doweled to the end of this shaft and the index pin has the usual spring to force it into the holes in the plate *R*.

The index plate or primary plate *R*, has 84 blind holes for the index pin to engage in, and also 84 teeth on its edge, to engage with the worm *U*, which is on a vertical shaft *V*, having at its upper end the ratchet wheel *X*. The casting *W*, in which *V* has a bearing, is fastened to *B* by a hub, shown dotted in Fig. 3, this hub being just a little above the meshing point of the worm *U*, and by loosening the screw *r* which binds the hub in *B*, the casting *W* may be rocked sidewise slightly to adjust the depth of mesh of the worm *U* in the teeth of *R*, and when at the correct depth, *r* may be tightened again. Shaft *V* is coned near the upper end, and the worm *U* which is splined to this shaft, is also coned at the top, the split nut at the lower end of *V* drawing the two cones to their seats, and making a snug running fit without shake.

Just below *X* are two arms *Y* and *Z*, shown in detail in Fig. 5, that are split and clamped to the outside of the spindle bearing in any desired position. *Y* and *Z* have pins projecting up and down from their outer ends, that form adjustable limits to the movement of the swinging arm *b*, carrying a pawl *e* that engages the teeth of ratchet *X*. The arm *b* is riveted tight onto a loose sleeve *a* that surrounds part of the vertical spindle bearing. The pawl *e* is reversible like a planer feed pawl, so it will move *X* either to the right or left. The ratchet *X* is made of sheet steel, and fits on a hub on the upper end of the spindle *V*, where it is held by a screw and also a single dowel pin in a collar on this spindle. The lower ends of the pins in *Y* and *Z* form the limits to the movement of arm *b* on the back stroke, while the upper ends of these same pins limit the motion of the pawl *e* on the forward stroke, as shown in Fig. 4. The construction there shown absolutely prevents the ratchet from going too far by its momentum, should the movement be sudden, as the pawl is jammed between the limit pin and the ratchet teeth, yet the pawl ends being slightly tapering, it easily withdraws from its locking position without any tendency to turn the ratchet backward. There is a stud *c* riveted tight in the end of arm *b*, as shown in Fig. 6. The sleeve *f* rides loosely on *c*, and is held from lifting off by the screw *d*, which also serves as a handle by which to do the secondary feeding. The pawl *e* is forced tight onto sleeve *f*. The piano-wire spring *g* is shaped like a fire poker, and is fastened to *b*, while its upturned and pointed end goes loosely through a hole in *b* and *c*, and enters either of two conical seats in the lower side of the flange on *f*, these seats being so located in relation to the pawl teeth that the spring point in entering them will force the pawl into the ratchet teeth. There are three ratchets, any one of which may be used as a secondary, one having 100 teeth, another 119, while the third has 143 teeth.

The selection of the numbers of teeth in the various wheels in this outfit, especially the secondaries, may seem a trifle strange, until the reason for so doing is apparent. The device was made so that all numbers could be indexed, some exactly, while others were only approximately indexed, but I wished to have the approximations as few as possible. Any number can be indexed exactly all of whose prime factors are found either in the main wheel *D*, the primary plate *R*, or the secondary ratchet *X*, so the numbers of teeth were so selected as to give a good assortment of prime factors; that is, a large number of 2's, not quite so many 3's, a few 5's and 7's, and one each 11, 13 and 17, as per table below.

Main Wheel	$120 = 2 \times 2 \times 2 \times 3 \times 5$.
Primary	$84 = 2 \times 2 \times 3 \times 7$.
Secondaries.....	$100 = 2 \times 2 \times 5 \times 5$. $119 = 7 \times 17$. $143 = 11 \times 13$.

By having ratchets with 119 and 143 teeth, all the low multiples of 11, 13 and 17 can be indexed exactly. Of course, it will be understood that in searching for the prime factors of the number we wish to index, only one of the secondaries may be used in combination with the primary and the main wheel. In case all of the

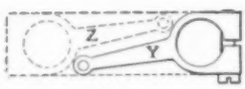


FIG. 5

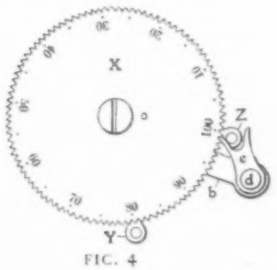


FIG. 4

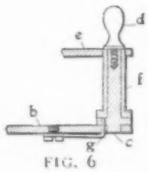


FIG. 6

FIG. 7

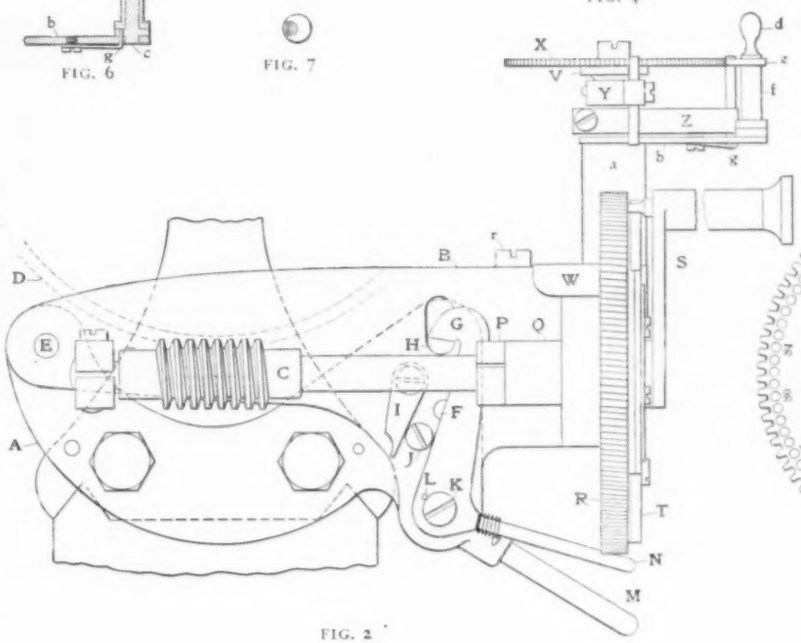


FIG. 2

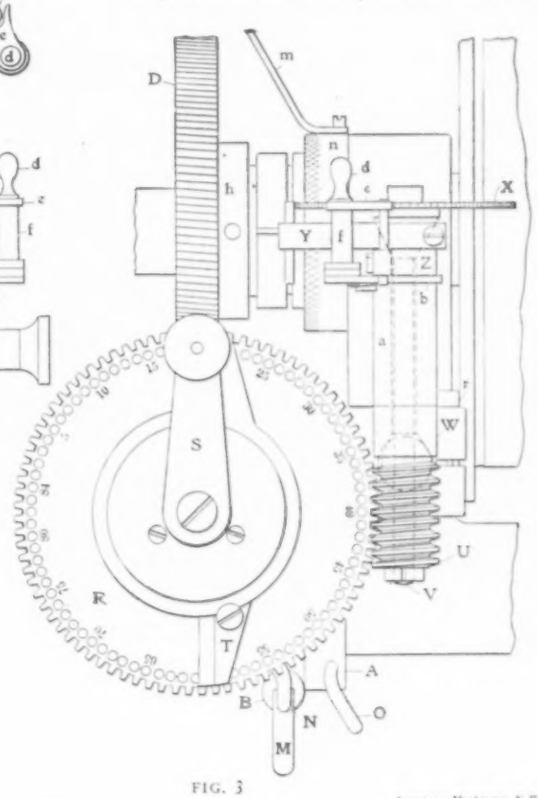


FIG. 3

American Machinist, N.Y.

CONSTRUCTION OF BENCH LATHE DIVIDING ATTACHMENT

prime factors of the gear to be cut cannot be found in the table of factors, then the indexing can be done approximately by occasionally omitting to feed one tooth of X, or else feeding one tooth more than ordinary, as the particular case calls for.

Number to be Indexed.	Whole Turns.	Primary Move.	Secondary Move.	Aggregate Error. Teeth to be Added.	Aggregate Error. Teeth to be Omitted.
60	2				
61	1	81	$+\frac{28}{143}$	10	
62	1	79	$-\frac{30}{143}$		2
63	1	76			
64	1	73	$+\frac{50}{100}$		
65	1	71	$+\frac{115}{143}$		
66	1	69	$-\frac{130}{143}$		
67	1	66	$+\frac{104}{143}$	2	
68	1	64	$+\frac{78}{110}$		
69	1	62	$+\frac{52}{110}$	24	
70	1	60			
71	1	58	$-\frac{1}{143}$	2	
72	1	56			
73	1	54	$+\frac{50}{100}$	16	
74	1	52	$+\frac{115}{143}$		6
75	1	50	$+\frac{50}{100}$		

PORTION OF INDEX TABLE.

A section of the index table that goes with this device is shown to give an idea of how it is used. In cutting a gear with 63 teeth, for example, the crank S would be given one whole turn and 76 holes on the plate R. To cut 64 teeth the crank S would be given one whole turn and 73 holes on R, and also the 100-tooth ratchet would have to be moved 50 teeth, moving the ratchet in such a direction that its movement carries the work in the same direction as the primary move carries it. To cut 61 teeth the crank S would be given one whole turn and 81 holes on the plate R, and also the 143 ratchet would have to be moved 35 teeth in the same direction as the primary move; besides this, at 10 places during the job, 36 teeth would have to be moved on the secondary or one extra tooth added to the secondary move after cutting every sixth tooth in the gear.

The worm wheel D has every fifth space between the teeth numbered on the side toward the lathe head, and a pointer m screwed fast to a ring n on the end of the spindle bearing serves to keep track of the divisions as the work is indexed around. This ring was put on by the makers, its office being to cover up an oil hole in the spindle bearing and keep out the dirt, but I screwed on the pointer m and made this ring do double duty. When this apparatus is off the lathe, and I have any indexing to do that can be done by the holes in the belt flange, I unscrew the pointer m and turn it around so it leans to the right, when it can be used to keep track of these holes, every fifth one of which I numbered, although the regular index pin, furnished by the maker, is used to lock the lathe spindle in position, the pointer only being used to count the holes as they pass it. As the ring n fits with a good, stiff friction, there is little danger of the pointer being moved accidentally during the job. For this use of an adjustable pointer in connection with the row of holes supplied by the maker of the lathe, I am indebted to C. H. Russom.

When the apparatus is on the lathe, and I wish to index any number that is a divisor of 120, I do it without using the crank S at all; simply drop C out of mesh, turn D the proper amount by hand, as indicated by pointer m, and then raise C into mesh again.

It will be noticed in the section of the index table that some of the secondary movements are marked minus. The reason of this is that I never give the secondary ratchet more than a half turn, as the handle d in one part of its travel comes rather close to the largest step of the cone pulley, so that where more than a half turn would otherwise be necessary, I move one more hole on the primary plate and then move the secondary in the opposite direction by an amount which its forward movement would have lacked of being a complete turn. In this way none of the secondary movements will be over half a turn. When the secondary movement is in the opposite direction to that of the primary move, it is a good plan to make the secondary move first and the primary move afterward, as in this way any error due to lost motion would be reduced to a minimum. As a matter of fact, I always make the secondary move first, if any is required, even if it is in the same direction as the primary move, so as to keep myself in training.

In Fig. 3 it will be noticed that every fifth hole in the plate R is numbered, which is simply for convenience in setting the sector T when starting on a job. A further use of these numbered holes is in detecting any carelessness in indexing that may have occurred during the progress of the job. By noting if the primary index pin is in the same hole at the finish as it was at the start, providing the secondary was not used, it is a pretty sure indication that no mistakes have been made in the indexing. Or when the secondary is in commission, the number of holes apart for the starting and finishing positions of the index pin should be equal to the number of complete turns the secondary has made during one whole turn of the lathe spindle. In Fig. 4 every fifth space of the secondary is center-punched, and every other center-punch mark is numbered, as a convenience in setting the limit arms Y and Z, and also to note if the stopping position is the same as that of starting.

In regard to the approximations, they are so in theory only, and in actual practice they are as exact as any of the other moves where no teeth have to be added or omitted, as the value of one tooth on the 100 ratchet, when reduced to the movement of the lathe spindle, is about 1¼ seconds of arc, which is considerably less than the probable errors existing in the worm wheel D, even if made with the care bestowed on graduating machines for astronomical circles, many of which work automatically in a closed room to eliminate errors due to the temperature of the workman's body. In fact, when the apparatus here shown was first constructed and before getting thoroughly familiar with its working, I made a mistake of one hole on the plate R while cutting a 28-tooth gear, and knew that the mistake was made because the index pin was not in the same hole at the finish as it was at the start, which was equivalent to omitting 100 ratchet teeth all in one spot, yet after the gear was cut, no error could be detected by careful feeling when meshing with another gear cut correctly.

The Hannifin Pneumatic Countershaft

EDITORIAL CORRESPONDENCE

A new reversing countershaft that is operated by air has recently been brought out by the Hannifin Manufacturing Company, of Chicago, Ill. It is shown as it is fitted up with hangers and a cone pulley by Fig. 1, while in Fig. 2 it is shown without hangers or cone pulley, in both of which styles it is marketed. The different

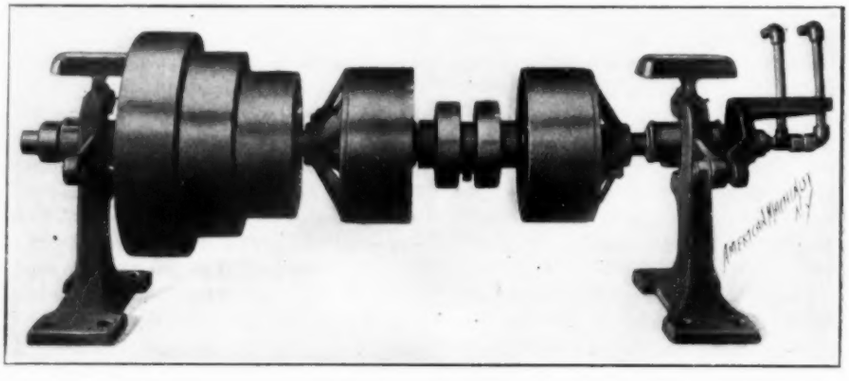


FIG. 1. HANNIFIN PNEUMATIC COUNTERSHAFT

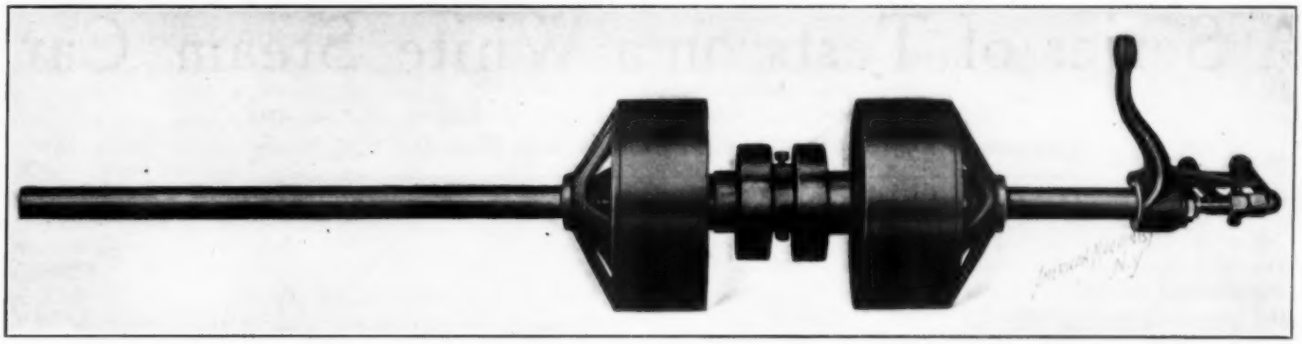


FIG. 2. COUNTERSHAFT WHEN SHIPPED WITHOUT HANGERS AND CONE PULLEY

parts which go to make up the countershaft are shown in Fig. 3.

The hanger, which is supplied with the countershaft is shown in the left of the illustration, and the shaft which holds all the apparatus is shown by *A*. This shaft has the center drilled out down to where the cylinder *B* fits on it. Inside of this drilled hole is located a tube, which is shown by *M*. The tube is small enough to allow an air space around it and through this space the air is carried to the farthest cylinder; while the air to the nearest cylinder is sent through the tube. In this way there is no danger of the air leaking from one cylinder to the other. The two cylinders are cast in one piece, as shown by *B*, one cylinder being in each end of the casting. Inside of the cylinder is inserted a piston *C*, which grips the sides of the cylinder by means of the cup-shaped packing shown. When the air is turned into the cylinder it not only forces the piston out, but also exerts a pressure against the packing so that it grips the side wall of the cylinder, thereby preventing any leakage of air. This makes a much more effective arrangement than would piston rings.

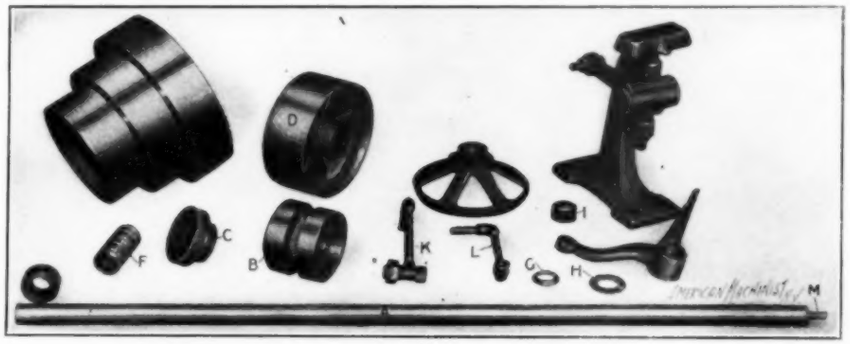


FIG. 3. DISASSEMBLED PARTS OF THE PNEUMATIC COUNTERSHAFT

The pulley which carries the belt from the line shaft is shown by *D*. Two of these are used, one on each side of the cylinder. Inside of this pulley fits the cone clutch *E*, which is fastened to the shaft by two set screws 120 degrees apart and kept from turning by a key. This grips the pulley when the air is turned on, and makes the entire shaft turn as one piece, with the exception of the pulley on the opposite side of the cylinder, which then acts as a loose pulley. The pulleys are supplied with a bronze bushing as shown at *F*, in order to reduce the wear to a minimum.

The square section spring *I* is located between the cone and the pulley, so that when the air is turned off it will throw out the clutch, and allow the pulley to run loose.

The way the different parts are assembled on the shaft is shown in Fig. 4. The parts to the right are all shown in place, while those to the left are shown separated. The double air cylinder casting *B* is fastened to the shaft with a set screw, and kept from turning on it by a key. The piston *C* is then shoved into place, and a split bevel bronze washer *G* is fitted into the piston, so that when the air is turned on it will grip the shaft and not allow any air to leak out. Next to this a fiber washer *H* is placed, which is brought in contact with the pulley *D* when in operation. On the opposite side of the pulley *D* another fiber washed is placed, and the square section spring *I* presses against that, while the spring in turn presses against the clutch *E*.

This construction reduces the wear to a minimum, as in no place in the countershaft does iron rub against iron, steel against steel, or steel against iron. When the piston is forced out by the air, the piston, bronze and fiber washers, pulley, and cone clutch are all gripped tightly together. When the air is turned off there is about ⅛ of an inch play between the piston *C* and the cone *E*, which allows the several parts to revolve freely without rubbing against each other.

The pipe connections *K* and *L* in Fig. 3 are connected to the ends of the shaft as shown in Figs. 1 and 2. These are held in position by fastening them to the casting *J*, which slips over the shaft and is held rigid by holding it in the shifter projection of the hanger. With this arrangement air can be piped to the countershaft through rubber tubes or with any other means desirable. The only other thing that is needed, to operate the countershaft, is an air valve, and this can be located on the machine or in any other place that is within easy reach of the operator.

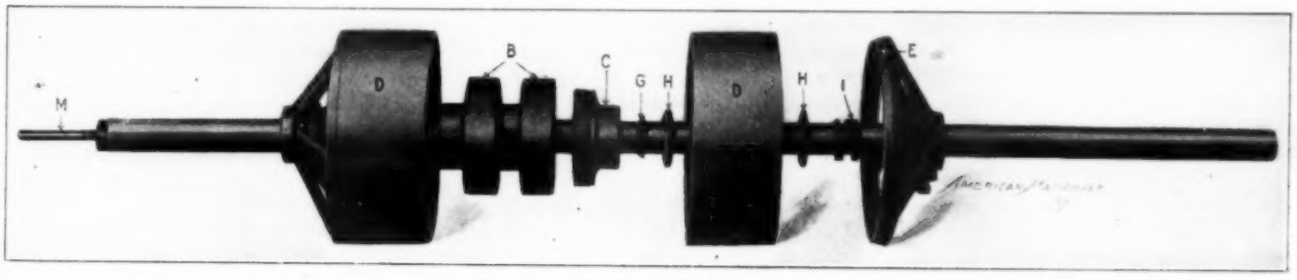


FIG. 4. COUNTERSHAFT PARTLY ASSEMBLED

A Series of Tests on a White Steam Car

To Determine Horse-power Output in Terms of Engine Rating and Economy at Different Speeds and Loads, Results Presented Graphically

BY C. H. BENJAMIN AND G. A. YOUNG

The object in mind in conducting a series of tests* on the White steam car, at the automobile testing plant at Purdue University, was to determine the output horsepower at the driving wheels in terms of the rated horsepower of the engine and the economy at different miles per hour and different loads.

The White steam car, as is known, is manufactured by the White Company, of Cleveland, Ohio. An expert engineer, representing the company, in the person of William Scaife, or Walter Grothe, M. E., was present at all tests. Acknowledgment is hereby made for their valuable assistance in arranging for the tests as well as the ability they displayed in maintaining the conditions desired. The tests were started on March 12, and continued until March 27, 1908.

Summary of Conclusions

1. The capacity of the engine on the White steam car exceeds its commercial rating by more than one-third.

2. It is capable of developing a net horsepower (that is, driving power on the ground) for 12.65 pounds of water and 1.23 pounds of gasolene per hour when run at a capacity exceeding its rating by 10 per cent.

3. The boiler is capable of evaporating from 13 to 14 pounds of water from and at 212 degrees Fahrenheit for each pound of gasolene burned and the boiler efficiency under full load is from 65 to 70 per cent., or about the same as in a larger boiler plant burning soft coal.

4. The water rate for speeds from 20 to 35 miles per hour and for powers from 20 to 35 horsepower is nearly constant, ranging between 12½ and 15½ pounds per horsepower-hour.

5. Between the limits of speed and power just mentioned, the fuel rate ranges between 1.1 and 1.4 pounds of gasolene per horsepower-hour. As in the case of locomotives, there seems to be a critical speed at which the efficiency is maximum. In the engine tested, this is about 30 miles per hour.

6. For loads in excess of one-half the rated capacity, there is little choice between a boiler pressure of 600 and one of 400 pounds, but for loads less than one-half the rating the lower pressure is more economical.

7. The use or disuse of the auxiliaries, such as fan, condenser and air pump, has but little effect upon the economy of the machine.

8. The use of the feed-water heater improves the fuel economy about 8 per cent., but has no perceptible effect on the water rate.

9. Two engines, one of which had to its credit 1400 more miles of travel than the other, give almost parallel results as to steam economy, the older engine having slightly the advantage as might be expected.

10. The tests described in this paper differ from those heretofore made in that the whole machine was in operation and was running under road conditions. The horsepower measured is that delivered by the driving wheels to the supporting wheels and corresponds to the net hauling power of the machine. If the indicated horsepower of the engine had been used in the calculations, the figures for efficiency would have been still better.

Description of the Car

The car tested was a chassis of the 1908 model, complete in every detail except the tonneau, which was of seven-seating capacity. The frame was wood armored with high-tension steel plates thoroughly bolted and riveted. The frame was equipped with long half-elliptical springs. The wheel base was 112 inches long. The wheels were 36-inch wood artillery, equipped with 36x4-inch Goodrich tube tires.

The Engine

The engine is of a compound-marine type with a high- and low-pressure cylinder, and with a high-pressure piston valve and a low-pressure slide valve operated by means of a Stephenson link motion. Ordinarily steam from the boiler is admitted to the high-pressure cylinder in the compound engine, but in order to start from any position in which the engine may be, it is necessary to admit high-pressure steam into the low-pressure cylinder. This is accomplished by means of a simple device easily accessible to the operator. The engine is equipped throughout with ball bearings.

Directly connected to the engine and operated by means of eccentrics on the main shaft are two pumps which force water into the generator. Another pump known as the condenser pump, draws the water and air from the condenser and discharges the water to the water tank, while a fourth, designated as the power air pump, is used for maintaining the pressure on the fuel or for inflating the tires.

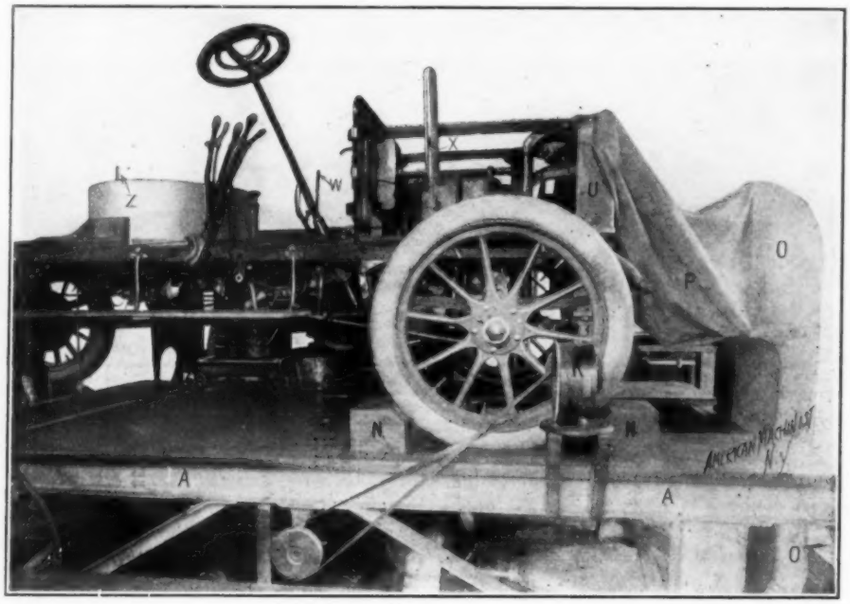


FIG. 1. CAR MOUNTED ON TESTING PLATFORM—FRONT AND RIGHT SIDE

*The running of these tests and the work involved in their calculations formed a part of theses of Messrs. G. W. Bohn, A. W. Durr, M. R. Rothenberger and F. B. Sale, candidates for the degrees of B.S. in mechanical engineering, 1908, at Purdue University. Acknowledgment is also made of the valuable services of O. C. Klipsch, M.E., instructor in mechanical engineering, who assisted throughout the experiments.

The Boiler or Generator

The White system of boilers or generators consists of a series of horizontal coils connected so as to form a continuous tube through which all the water fed to the boiler and all the steam taken from the boiler must circulate. There is no storage for either steam or water; the water is pumped in at the top and the highly superheated steam is taken out at the bottom. By this construction the circulation of the steam is opposite to the direction of the products of combustion. The safety valve on the boiler was set to blow off at 1200 pounds.

The Burner

The burner is made of cast iron with a vaporizer and pilot light. The vaporized gasolene enters tangentially and is thus distributed equally around the burner. A thermostat automatically controls the supply according to the needs of the engine.

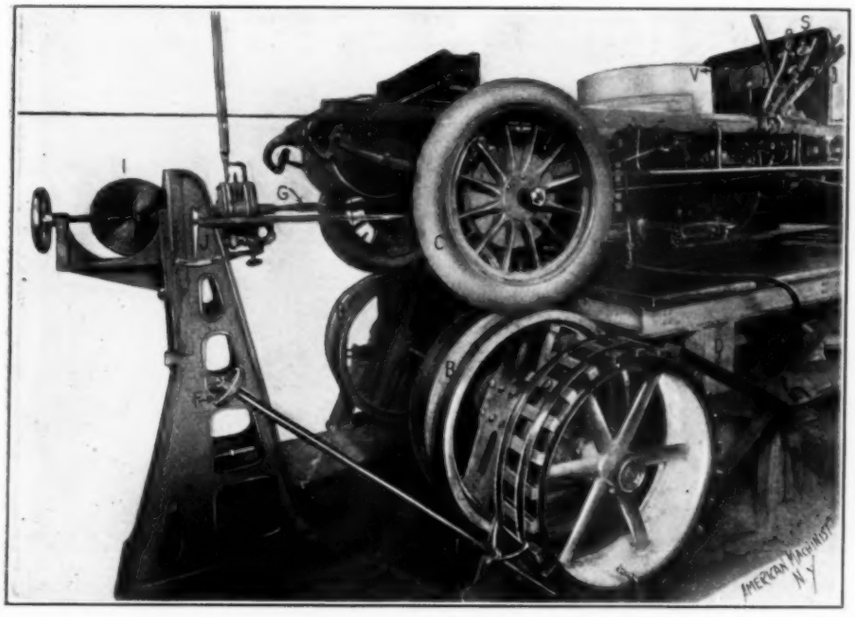


FIG. 2. CAR ON TESTING PLATFORM—PRONY BRAKE AND DYNAMOMETER

The Condenser

The condenser is made of four rows of flanged tubes connecting into a top and bottom chamber. The exhaust from the engine enters the top chamber and the condensed water is drawn out through the connection in the lower chamber. When there is more steam entering the chamber than can be condensed, the excess is by-passed through an adjustable check valve to the atmosphere.

Dimensions and Constants

(a) Engine:

Diameter of cylinders, 3-inch high pressure, 6-inch low pressure.

Diameter of piston rods, 9/16-inch high pressure, 9/16-inch low pressure.

Clearance of engine, 17.13 per cent. high, 18.65 per cent. low pressure.

Weight of cylinder castings with guides, 141 pounds.

Weight of engine frame complete, 137½ pounds.

Weight of valves and fitting, 75½ pounds.

Total weight of engine complete, 354 pounds.

Ratio of revolutions of engine to drivers, 2.5 to 1.

(b) Boiler:

Number of coils, 8.

Nominal internal diameter of tube, ¼ inch.

Nominal external diameter of tube, ¾ inch.

External diameter of boiler, 22 inches.

Hight of boiler, 11 inches.

Length of tubing in coils, 243 feet.

Heating surface of boiler, 45.8 square feet.

Weight of boiler without fittings, 200 pounds.

Weight of casting, bolts and all fittings, 45 pounds.

Total weight of boiler complete, 245 pounds.

Weight of burner, 36 pounds.

(c) General:

Total weight of boiler and engine complete, 635 pounds.

Revolutions of supporting wheels to the mile, 576.1.

Average area of contact between rubber tires of drivers and supporting wheels, right wheel, 18.81 square inches, left wheel, 18.52 square inches.

(d) Table of Revolution of Engine at Different Miles per Hour, Based on Revolutions of the Supporting Wheels:

Miles per hour.	Revolutions per Minute of Engine.
15	360
20	480
25	600
30	720
35	840
40	960
45	1080

The Automobile Testing Plant

The arrangement of the automobile testing plant at the Purdue University may be seen in Figs. 1 to 4. A brief description will bring out some points not apparent at first glance. The platform *A*, Fig. 1, upon which the car is placed, is about 3 feet high and supports the front wheels. At the rear of this platform are the wooden supporting wheels *B B*, Fig. 2, upon which the rear driving wheels *C C*, are placed, the upper edges of the wooden pulleys being on a level with the platform. The bearings of the shaft to which these pulleys or supporting wheels are fastened, are placed on the outside of the wheels. The resistance to the turning of the wooden pulleys and through them to the drivers of the car is given by a prony brake *D*, Fig. 2, various adjustments being made by means of the hand wheel *F*. The pull of the car being tested is transmitted through a flexible draw bar *G*, fastened to the rear axle, through a dashpot *H*, and read on a calibrated scale *I*. The pull on the dynamometer scales is regulated by the simultaneous adjustment of the hand wheels on the brake and scales. The accuracy of the reading on the scales depends upon the position of the center line of the drivers in respect to the center line of the shaft of the supporting wheels. In order to insure that the center of the driver is vertically above the supporting wheel shaft, very careful tram measurements locate the correct position and this position is then maintained, as indicated by the pointer *J* in Fig. 2, which moves horizontally with the rear axle. A revolution counter *J*, Fig. 3, on the brake-wheel shaft indicates the revolution of the supporting wheels.

The exhaust gases are drawn off by means of a fan, which is motor driven. Another fan delivers air to the front through the duct *O*, Figs. 1 and 4 and *P*, Fig. 1, for air-cooled engines or condensers. Both of these motors and fans are located under the platform and may be seen in Fig. 3. The rheostats, which control the speeds of these, may be seen in Fig. 4 to the right.

The tachometer is driven directly from the supporting wheel shaft, placed where the engine and dynamometer operators may see it, and is shown in *K*, Fig. 1. The fuel is measured in a calibrated tank, or weighed in a tank on scales.

It will be seen that the power measured is the power delivered by the driving wheels. The friction losses included the mechanical losses through the transmission shaft, gear case, rear axles, and tire friction and slippage.

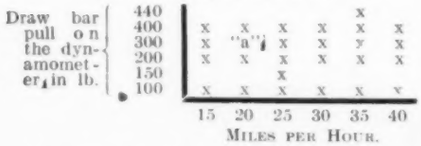
The adjustable wooden blocks *N N*, Figs. 1 and 4, are set so as to give about 1-inch clearance for the front wheels.

Outline of Tests

The field covered by the number of tests run can be divided into two groups and may be shown graphically. In all series of tests an effort was made to maintain the superheat at the boiler between 300 and 350 degrees Fahrenheit and at the exhaust from 10 to 50 degrees Fahrenheit.

Group I

SERIES *A*. CONSTANT BOILER PRESSURE OF 600 POUNDS, ENGINE NO. 1.



A study of the above diagram will show that there were six series of tests run under this group and that each series contains from three to five separate tests. Thus, the test marked *a* on the above diagram will be found designated all through as *A* (600 — 20 — 300). The term *A* referring to the series of constant steam pressure of 600 pounds in Group 1. The remaining terms in order from left to right indicate pressure pounds per square inch, miles per hour and draw-bar pull in pounds.

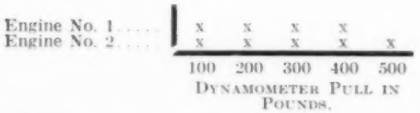
Group II

Under this group a number of series were run at different percents of cut-off as designated by the notch, at different steam pressures with and without the condenser, fan or air pump, with and without the heater and with a new engine just from the shops designated as engine No. 2.

Series B. Constant boiler pressure of 400 pounds, engine No. 1. There were four tests in this series all at the speed of 25 miles per hour and at 100, 200, 300 and 370 pounds pull on the dynamometer.

Series C. Constant boiler pressure of 600 pounds, engine No. 1. This series of tests was run without the brake, therefore any draw-bar pull registered on the dynamometer would be due to the friction of the supporting wheels. The miles per hour were different for each test and were taken at 20, 25, 30 and 35.

Series D and D'. Constant boiler pressure of 600 pounds, constant speed of 30 miles per hour. Tests run without the condenser, fan or air pumps, and shown diagrammatically below.



Engine No. 1 on the car when chassis arrived.

Engine No. 2 new engine just arrived from the shop.

Series E. Constant boiler pressure of 600 pounds, engine No. 2, constant miles per hour of 30.

This series was run without heater, fan or condenser, or air pumps at four draw-bar pulls, viz., 100, 200, 300 and 400 pounds.

Series F. This series covers the same range as series E of dynamometer readings, viz., 100, 200, 300 and 400 pounds, but differs in that the heater, fan, condenser and air pumps were used.

Note. The above series outlined in Groups I and II consist of 49 tests. The complete series run make a total of 84, of which 10 were duplicate and the remaining 25 tests covered other points and are not to be included in this paper.

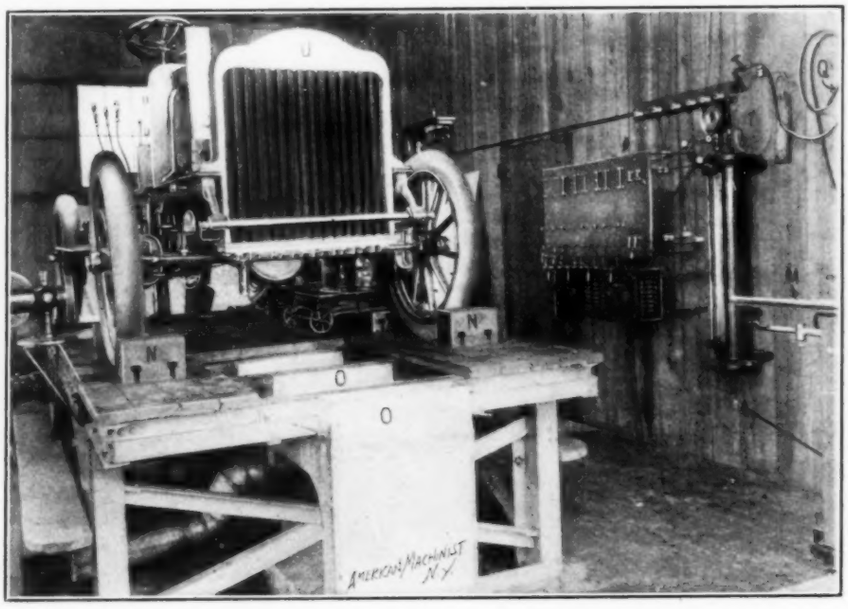


FIG. 4. CAR ON TESTING PLATFORM, FRONT VIEW—RHEOSTATS, SWITCHES, ETC., AT THE RIGHT

The same designation of tests will be used in Group II as was used in Group I.

Method of Operation

Preliminary Running—The engine and drivers were warmed up while the conditions of each test were becoming normal. When the engine was started cold, usually a run of an hour or more was made under the exact conditions to be maintained. Between tests, the engine and drivers were not shut down. The new conditions being obtained, a run of at least 30 minutes was made after these conditions were constant.

Constant Conditions—Extreme care was taken to secure uniform conditions throughout each test. If any change occurred, no further readings were taken and data secured was thrown out, while the conditions were again secured. The constant conditions maintained were the degree of superheat at the boiler, boiler pressure, revolutions of the engine and dynamometer pull.

Automatic Regulation—When the engine is in operation, it operates the feed-water pumps. The water regulator either by-passes all of the water thrown by the pump, as when the steam pressure exceeds 600 pounds, or it allows all of the water to flow toward the generator or boiler, as when the steam pressure is less than 600 pounds. That is to say, the water supply is controlled by an "all on" and "all off" method, the required variations being due to changes automatically brought about in the frequency and durations of these "all on" periods. The water flows through two branches, in one of which is a flow motor and in the other a valve controlled by a thermostat. The water going through the flow motor moves a piston therein, which, in turn, proportionately opens the fuel valve. It also opens the relief valve when the rate of flow water into the flow motor exceeds the capacity of the generator, and by-passes the excess water. The ratio between fuel supply to the burner and water supply to the generator is varied by the action of the thermostat on the valve, which increases or decreases the rate at which water flows past the valve through the shunt branch. The practical result of the automatic action of the described parts is to maintain the steam at practically uniform high pressure and high temperature under all working conditions without any hand manipulation of any kind, and without requiring any attention from the operator. All he has to do is to manipulate his throttle so that the engine will get the steam required for the running of the car at the desired rate. The automatic regulating system so oper-

ates that the steam used is immediately replenished without any substantial variations of pressure or temperature.

Duration of Tests — As originally planned, each test was to be of 30 minutes' duration, and in nearly all instances the idea was carried out. In a few tests the readings showed such uniform results that the tests were shortened to 20 minutes.

Observations—All observations were taken simultaneously every five minutes throughout each test, excepting the barometer reading, which was taken once every test.

Fuel—The gasolene to be used was tested by a hydrometer before placing in the tank. This closed tank held about 200 pounds of fuel and was placed on a pair of sensitive platform scales. The connection *Q*, Fig. 4, for maintaining an air pressure of from 40 to 70 pounds on the fuel, according to the load as well as the supply pipe leading to the burner at the boiler, was made so flexible that the sensitiveness of the scale reading was not impaired. The scale was carefully balanced at each reading; the sum of the differences, which were nearly constant, would give, of course, the weight of fuel used for that test.

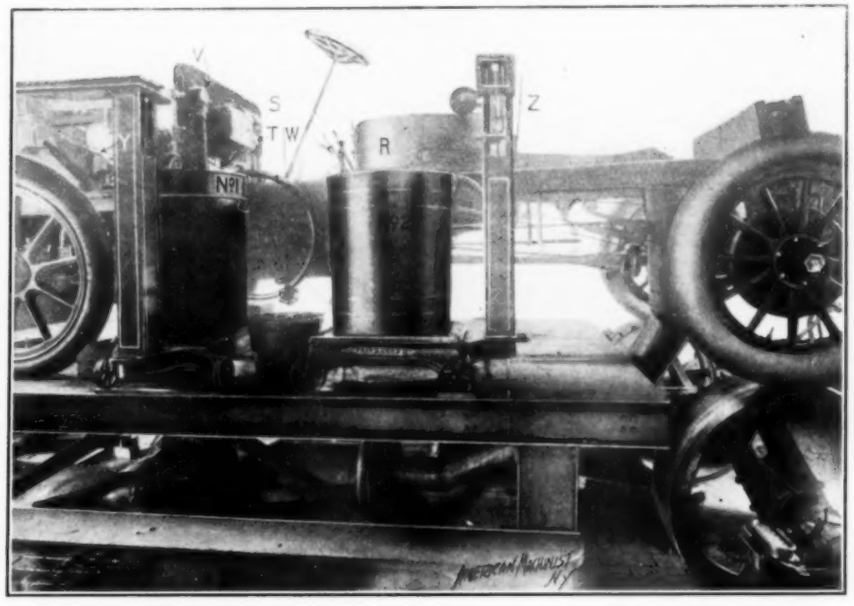


FIG. 3. CAR ON TESTING PLATFORM—PRESSURE GAGES AND WEIGHING TANKS

Water—The supply of water to the boiler on the White steam car is carried in a tank between the engine and generator *R*, Fig. 3, the returns from the condenser pump, from the overflow, from the water regulator and from the by-pass of the flow motor being delivered to this tank. During the tests, the water was weighed in an open tank, No. 1, Fig. 3, placed on platform scales. The return from the overflow from the water regulator and from the by-pass of the flow motor was delivered into this tank, No. 1, through flexible tubing. The return from the condenser pump was still delivered to the tank on the car and was drawn off when necessary. Ordinarily, the capacity of the tank was sufficient to enable a run of 30 minutes to one hour without being refilled. In case of heavy loads, a weighed quantity of water was put in from a similar tank, No. 2, on another pair of scales. The temperature of the feed water was taken by a thermometer placed in the tank, No. 1. At the instant of starting a test, the beam was balanced and the water and the tank weighed. This was repeated every five minutes during the test. It was remarkable how closely these differences would check for succeeding five-minute periods during the continuation of the test.

Dynamometer—The brake *D*, Fig. 2, on the shaft of the supporting wheels, which was adjusted by an operator stationed at this position, produced the draw-bar pull, which pull was registered on the dynamometer scales. During each test, a constant dynamometer reading was maintained. The revolutions per minute of the supporting wheels were obtained by means of the revolution counter operated by the shaft of the supporting wheels. In heavy loads, the brake arm was solid against the "stop" so that the brake horsepower in such cases could not be obtained. The greatest care was maintained by this operator to keep the indicator *J*, Fig. 2, pointing at the zero mark, which meant that the center line of the driving wheels was perpendicularly above the center line of the supporting wheels.

Pressure of the Steam

The steam pressure on the generator or boiler was taken on the gage *S*, Figs. 2 and 3, usually found on White steam cars, which reads to 1500 pounds.

Another gage *T*, in Figs. 2 and 3, of the same range was placed below the one just indicated, and was piped to the steam line between the throttle valve and the steam chest. Some trouble was experienced at first in throttling this pressure down to prevent excessive vibration, but this was finally overcome by filling the pipe connection full of heavy oil and inserting a small orifice in the union.

The pressure on the condenser *U* in Figs. 1 and 4 was measured on a gage *V*, in Figs. 2 and 3, which read above or below the atmosphere. The test with the smallest loads showed some back pressure.

Temperature of the Steam

The temperature of the steam was taken at the boiler *W*, in Figs. 1 and 3, at the engine between the throttle, and steam chest *X*, in Fig. 1, and in the exhaust port of the low-pressure cylinder *Y*, Fig. 3. At the boiler and engine steel thermometer cups were used partly filled with flake graphite. The thermometer cup made of brass inserted in the exhaust port, was half filled with heavy oil.

The thermometers used were of the best hydrogen filled and carefully calibrated and compared, and the same ones were used throughout all the series.

The degree of superheat at the boiler was adjusted by means of the thermostat to stand between 300 and 350 degrees for all loads and all miles per hour. No test was recorded in which there was not 10 or more degrees of superheat in the exhaust.

Flue Gases—The temperature of the flue gases was taken by means of a thermometer placed near the generator *Z*, in Figs. 1 and 2. The gases were drawn off by means of a fan and exhausted to the atmosphere. Care was taken not to produce an excess draft on the fire.

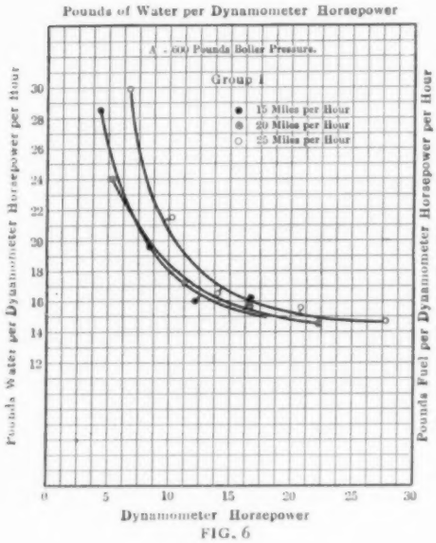
Tachometer—The speed of the engine could be noted at all times by the engine operator by means of the tachometer, which was connected to the shaft of the supporting wheels. The constant speed at the required miles per hour was maintained by adjusting the throttle of the engine.

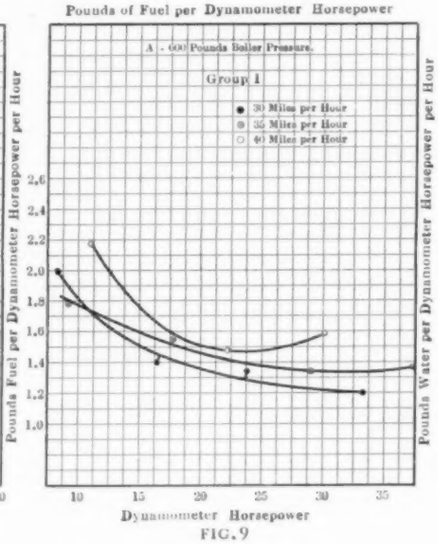
Method of Calculations

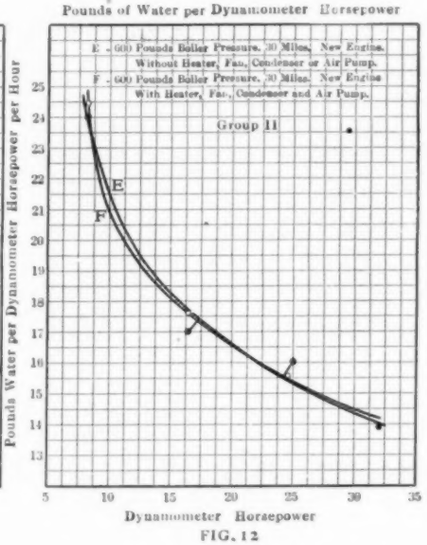
(a) Dynamometer Horsepower—The dynamometer horsepower, abbreviated to D.H.P., was calculated from the draw-bar pull registered on the dynamometer scale, the revolutions and diameter of the supporting wheels. From this it is seen that the dynamometer horse is the power delivered on the ground by the drivers. The engine has had to overcome all the friction in the transmission shaft, gear cases, rear axle bearings, tire and slippage losses, before delivering this output power.

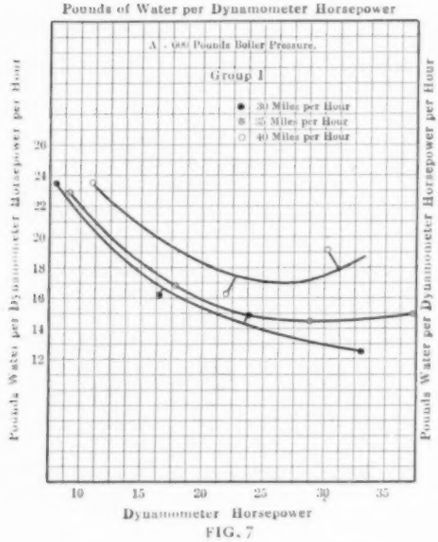
(b) Specific Heat—To the authors of this paper the results on the value of the specific heat of superheated steam at con-

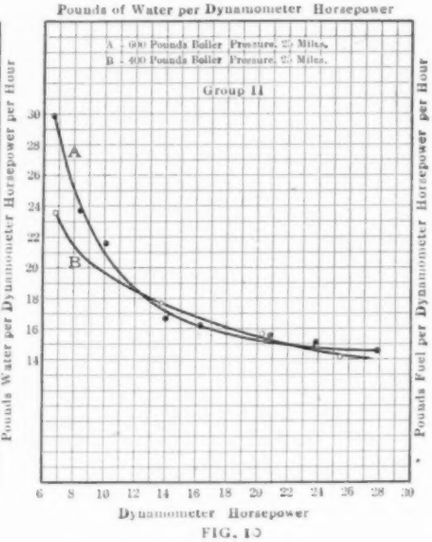
stant pressures, obtained by Professor Thomas, of Sibley College, Cornell University, are as reliable as any that have been obtained. Although in his investigation he did not carry his superheat above 300 degrees Fahrenheit and a pressure of 400 pounds absolute, his results have been used to estimate the value of the specific heat for various temperatures of superheat and pressures found in these tests on the White steam car. The following is the method of procedure: From a table giving Professor Thomas' results at 20, 50, 100, 150, 200, 250 and 300 degrees of superheat at 100, 200 and 400 pounds pressures, the full-line curves, shown in Fig. 22, were plotted. From the direction of the lines given from the data

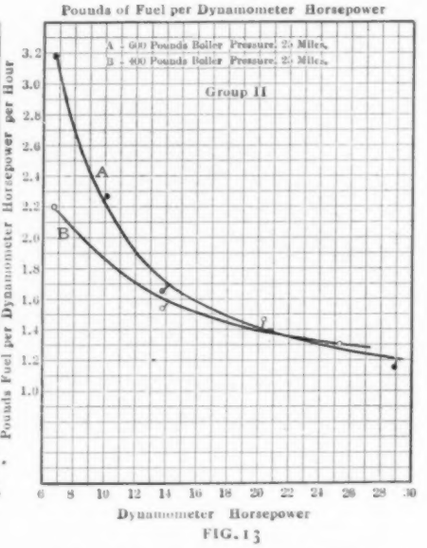

Pounds of Water per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure.
Group I
15 Miles per Hour
20 Miles per Hour
25 Miles per Hour
Pounds Water per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 6

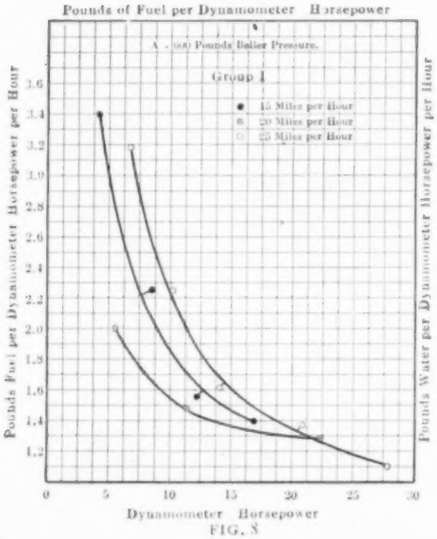

Pounds of Fuel per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure.
Group I
30 Miles per Hour
35 Miles per Hour
40 Miles per Hour
Pounds Fuel per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 9

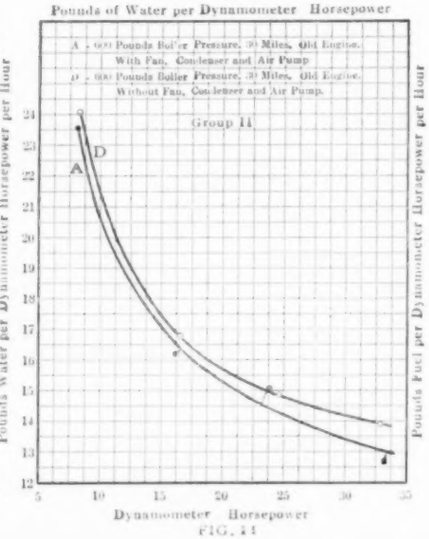

Pounds of Water per Dynamometer Horsepower
E - 600 Pounds Boiler Pressure, 30 Miles, New Engine, Without Heater, Fan, Condenser or Air Pump.
F - 600 Pounds Boiler Pressure, 30 Miles, New Engine With Heater, Fan, Condenser and Air Pump.
Group II
E
F
Pounds Water per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 12

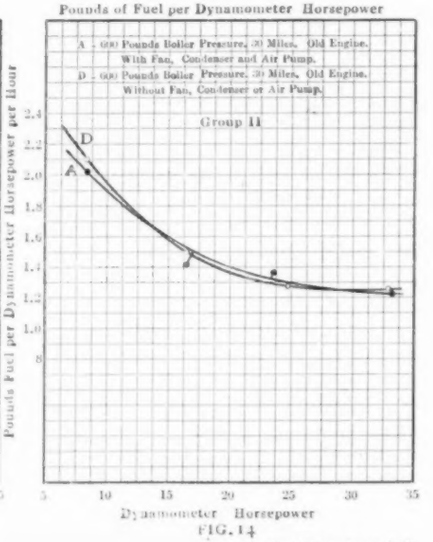

Pounds of Water per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure.
Group I
30 Miles per Hour
35 Miles per Hour
40 Miles per Hour
Pounds Water per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 7


Pounds of Water per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure, 25 Miles.
B - 400 Pounds Boiler Pressure, 25 Miles.
Group II
A
B
Pounds Water per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 10


Pounds of Fuel per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure, 25 Miles.
B - 400 Pounds Boiler Pressure, 25 Miles.
Group II
A
B
Pounds Fuel per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 13


Pounds of Fuel per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure.
Group I
15 Miles per Hour
20 Miles per Hour
25 Miles per Hour
Pounds Fuel per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 8


Pounds of Water per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure, 30 Miles, Old Engine, With Fan, Condenser and Air Pump.
D - 600 Pounds Boiler Pressure, 30 Miles, Old Engine, Without Fan, Condenser and Air Pump.
Group II
A
D
Pounds Water per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 11


Pounds of Fuel per Dynamometer Horsepower
A - 600 Pounds Boiler Pressure, 30 Miles, Old Engine, With Fan, Condenser and Air Pump.
D - 600 Pounds Boiler Pressure, 30 Miles, Old Engine, Without Fan, Condenser or Air Pump.
Group II
A
D
Pounds Fuel per Dynamometer Horsepower per Hour
Dynamometer Horsepower
FIG. 14

in hand, the lines were extended as indicated by the dotted lines to cover pressures of 500 and 600 pounds. This gave approximately the values of the specific heat of superheated steam at constant pressure of 500 and 600 pounds.

Another set of curves at 100, 200 and 400 pounds pressures was then plotted with specific heats as ordinates and degrees of superheat as abscissas, the value being taken from the same table of results given by Professor Thomas. These are shown in Fig. 23. Another curve for 600 pounds was then plotted using the approximate values of specific heat as found in Fig. 23. From this curve on Fig. 23 the value of specific heat at constant pressure for the desired pressures

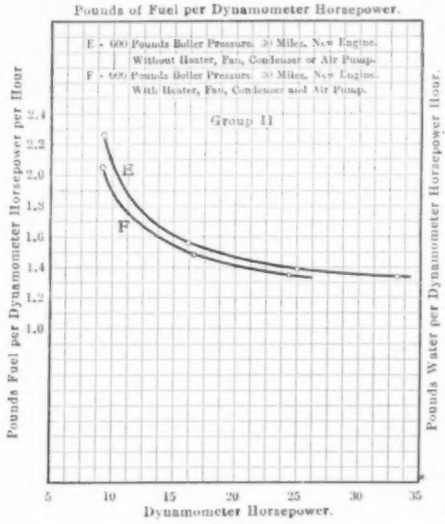

Pounds of Fuel per Dynamometer Horsepower.
E - 600 Pounds Boiler Pressure. 30 Miles. New Engine. Without Heater, Fan, Condenser or Air Pump.
F - 600 Pounds Boiler Pressure. 30 Miles. New Engine. With Heater, Fan, Condenser and Air Pump.
Group II
E
F
Pounds Fuel per Dynamometer Horsepower per Hour
Dynamometer Horsepower.

FIG. 15

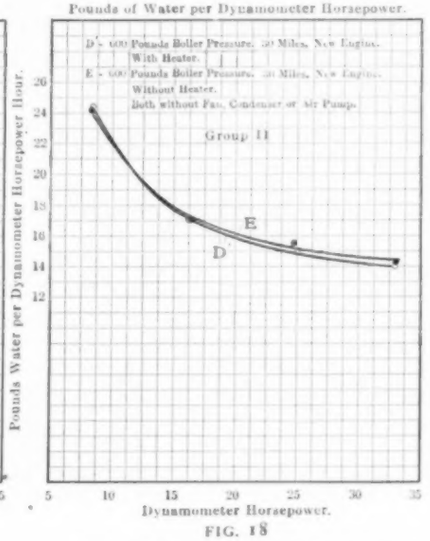

Pounds of Water per Dynamometer Horsepower.
D - 600 Pounds Boiler Pressure. 30 Miles. New Engine. With Heater.
E - 600 Pounds Boiler Pressure. 30 Miles. New Engine. Without Heater. Both without Fan, Condenser or Air Pump.
Group II
E
D
Pounds Water per Dynamometer Horsepower Hour.
Dynamometer Horsepower.

FIG. 18

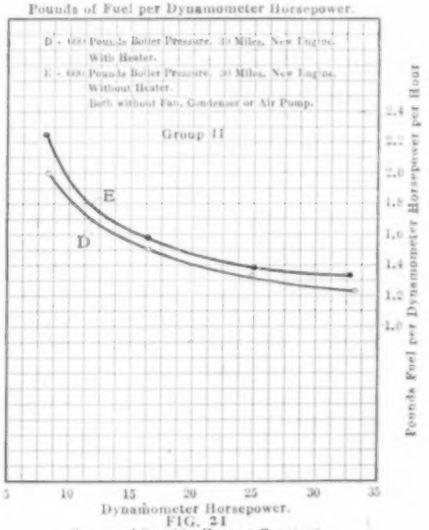

Pounds of Fuel per Dynamometer Horsepower.
D - 600 Pounds Boiler Pressure. 30 Miles. New Engine. With Heater.
E - 600 Pounds Boiler Pressure. 30 Miles. New Engine. Without Heater. Both without Fan, Condenser or Air Pump.
Group II
E
D
Pounds Fuel per Dynamometer Horsepower per Hour
Dynamometer Horsepower.

FIG. 21
Curves of Specific Heat at Constant Pressure of Superheated Steam.
From Tests of Prof. Thomas, Cornell University.

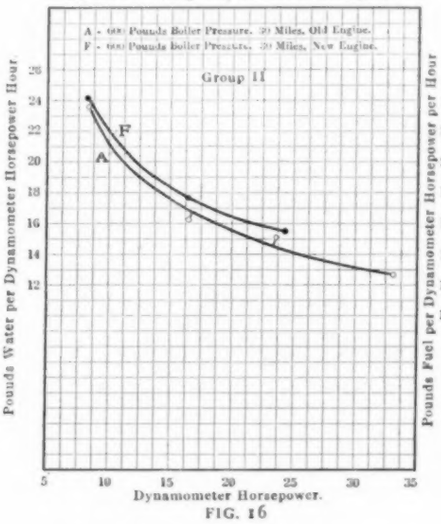

Pounds of Water per Dynamometer Horsepower.
A - 600 Pounds Boiler Pressure. 30 Miles. Old Engine.
F - 600 Pounds Boiler Pressure. 30 Miles. New Engine.
Group II
F
A
Pounds Water per Dynamometer Horsepower Hour
Dynamometer Horsepower.

FIG. 16

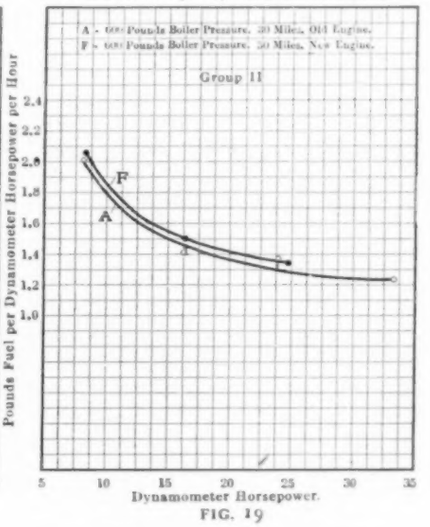

Pounds of Fuel per Dynamometer Horsepower.
A - 600 Pounds Boiler Pressure. 30 Miles. Old Engine.
F - 600 Pounds Boiler Pressure. 30 Miles. New Engine.
Group II
F
A
Pounds Fuel per Dynamometer Horsepower per Hour
Dynamometer Horsepower.

FIG. 19

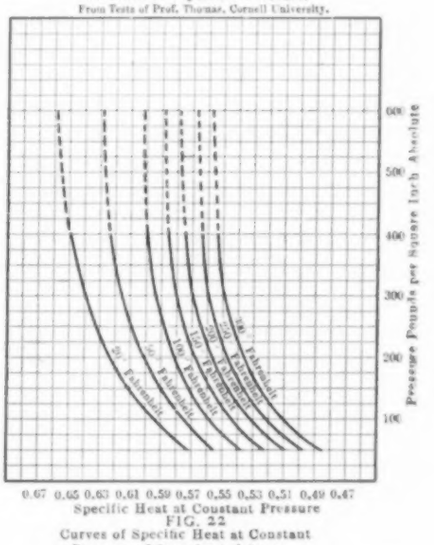


FIG. 22
Curves of Specific Heat at Constant Pressure of Superheated Steam.
From Tests of Prof. Thomas, Cornell University.

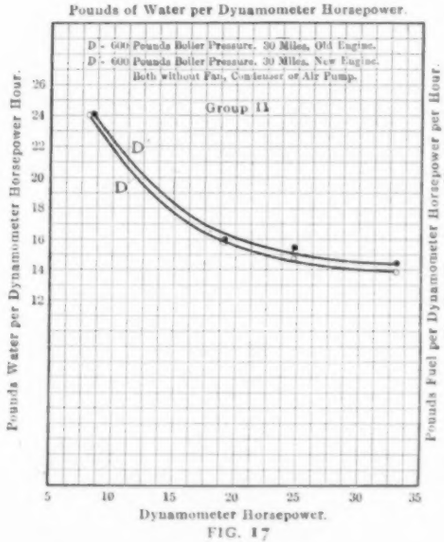

Pounds of Water per Dynamometer Horsepower.
D - 600 Pounds Boiler Pressure. 30 Miles. Old Engine.
D - 600 Pounds Boiler Pressure. 30 Miles. New Engine.
Both without Fan, Condenser or Air Pump.
Group II
D
D
Pounds Water per Dynamometer Horsepower Hour.
Dynamometer Horsepower.

FIG. 17

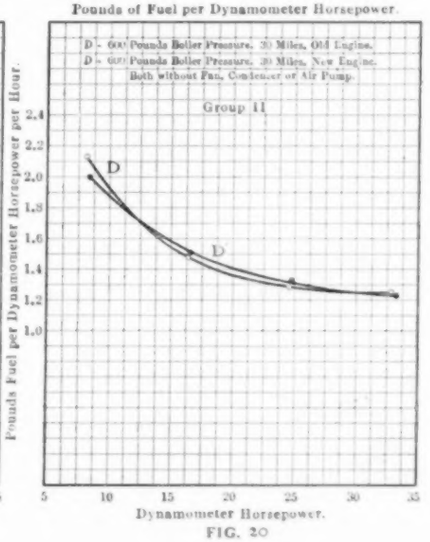

Pounds of Fuel per Dynamometer Horsepower.
D - 600 Pounds Boiler Pressure. 30 Miles. Old Engine.
D - 600 Pounds Boiler Pressure. 30 Miles. New Engine.
Both without Fan, Condenser or Air Pump.
Group II
D
D
Pounds Fuel per Dynamometer Horsepower per Hour.
Dynamometer Horsepower.

FIG. 20

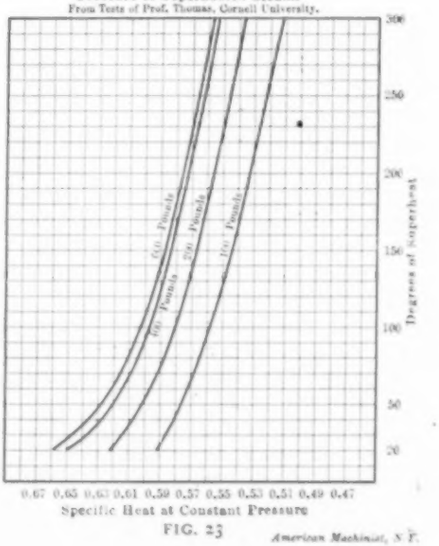


FIG. 23

American Machinist, N. Y.

and degrees of superheat was interpolated.

(c) British Thermal Units per Pound of Steam Under Boiler Conditions—The properties of saturated steam found in Professor Peabody's last edition, known as "Steam and Entropy Tables," have a maximum pressure range of 336 pounds absolute. In all calculations in determining the British thermal units per pound of steam these tables were used when possible. In many instances, however, the pressure was 600 pounds at the engines and in nearly all cases it was 600 or a little more at the boiler. This necessitated the use of another set of steam tables, and Nystrom's, as found in Suplee's "Handbook for Mechanical Engineers," was used. In these tables the properties of saturated steam are carried out for pressures as high as 1000 pounds. These values differ a little from the values obtained from Buel's "Tables of Saturated Steam" which Professor Carpenter used in his calculated results in 1906.

(d) Boiler Efficiency—The boiler efficiencies were based on gasolene with a heating value of 19,600 British thermal units per pound and a specific gravity of 0.70.

A table of significant results has been prepared giving the maximum and minimum as well as the average results.

Discussion of Results and Conclusions

In presenting this part of this paper it is not the intention of the writers to discuss the results in detail, but rather to let the graphical results to be found in Figs 6 to 21, tell their own story, with a little emphasis on a point here and there.

Group I

This group of 25 tests was to be run under the constant boiler pressure of 600 pounds and a superheat at the boiler of 300 to 350 degrees Fahrenheit. The car was run at six speeds, namely 15, 20, 25, 30 and 35 miles, and each speed with from three to five dynamometer loadings.

(a) Pounds of Water per Dynamometer Horsepower per Hour—In Figs. 1 and 2 it will be seen that, in general, the lower the speed of the engine, the better the water rate. Also that the economy increases rapidly as the load increases from a minimum dynamometer horsepower to 15 horsepower, and from then on to the higher loads less rapidly. At some speeds there is a slight increase in the water rate as the load gets above 25 horsepower, showing that the load of maximum economy for the speed has been passed.

The best results for any one test in this group was at 30 miles an hour at about 33 horsepower. The pounds of water per dynamometer horsepower-hour for this test was 12.6. The average of the best results for the tests under this group is 14.53 pounds per dynamometer horsepower-hour.

(b) Pounds of Fuel per Dynamometer Horsepower-Hour—The pounds of fuel per dynamometer horsepower per hour, Figs. 8 and 9, decrease rapidly as the load increases. This is especially true of tests at 15, 20 and 25 miles per hour. At the three higher rates of speed, 30, 35 and 40, the previous statement is not true, for all the curves are more nearly horizontal throughout, indicating that the fuel economy is good for a greater range of load. Another point which is evident upon a closer study, is that there is no decided decrease in the fuel rate as the speed decreases, as there was in the water rate, for if the six curves found on Figs. 8 and 9, were plotted to the same coördinate axes, those tests at 15, 20 and 25 would in general coincide with those tests at 30, 35 and 40.

The best result is at 25 miles, when a horsepower was produced on the ground at the rear drivers of gasolene per hour. The average of the best results gives 1.29 pounds per dynamometer horsepower per hour.

Group II

Explanation—In this group there were five investigations in mind which may be stated as follows:

(a) Relative economy of using a boiler pressure of 400 pounds and 600 pounds.

(b) Relative economy of a new engine, No. 2, just from the shops and an old engine, No. 1, which had run something over 1400 miles on the testing plant. When this engine arrived with the chassis, it was supposed to have run as much as No. 2, as both engines had been through the regular shop test.

(c) Effect on economy with and without the exhaust steam feed-water heater.

(d) Effect on the economy with and without the fan, condenser and air pump.

(e) Effect on the economy with and without the heater, fan, condenser and air pump.

Discussion

(a) Boiler Pressure of 600 and 400 Pounds, Figs. 10 and 13—There seems to be a decided advantage by using a boiler pressure of 400 instead of 600 pounds when the output power is 12 horsepower or lower. This is due to the fact that under higher loads, the steam is throttled at the engine even with 400 pounds pressure at the boiler. With a dynamometer horsepower of over 12, the two curves nearly coincide, with a little advantage in the water rate with the higher pressure. The fuel economy favors the low pressure with small loads up to 21 dynamometer horsepower. The average boiler efficiency at 400 pounds was 69.8 per cent. and for 600 pounds 68.5 per cent.

(b) Old Engine No. 1 and New Engine No. 2 (Figs. 16, 17, 19 and 20).

Two sets of curves have been plotted to show the difference in economy of a new engine and one which had been run over 1400 miles. Fig. 16 shows the relative performance of the two engines with all the auxiliary in operation, and Fig. 17, the performance without the fan, condenser and air pump. The engine No. 1, gives a better economy by 4.1 per cent. than engine No. 2, as may be seen in Figs. 16 and 17. The fuel per dynamometer horsepower per hour, to be seen in Figs. 19 and 20, indicates a very small advantage in favor of the old engine.

(c) With and Without the Feed-Water Heater, Figs. 18 and 21—In the series, *E* and *D'*, both were run without the fan, condenser and air pump and with and without the exhaust steam feed-water heater. The results are shown in Figs. 18 and 21. As might be expected, the water consumption per dynamometer horsepower per hour is practically the same. The pounds of fuel per dynamometer horsepower per hour shows a saving of 8 per cent. when using the heater.

(d) With and Without the Fan, Condenser and Air Pump, Figs. 11 and 14—The plotted results shown in Figs. 11 and 14, give a comparison with and without the fan, condenser and air pump. Strange to say the pounds of water per dynamometer horsepower is lower for the engine using the fan, condenser and air pump. The back pressure in this series was 18 pounds absolute and without the fan, condenser and air pump, about 15 pounds absolute. The results shown in Fig. 14 for the two series are about the same as would be expected. Both series *A* and *D* were run off on the old engine No. 1. A comparison of series *D'* and *F* on the new engine No. 2, with and without the fan, condenser and air pump, indicates the same difference as above stated but not in so marked a degree.

(e) With and Without the Heater, Fan, Condenser and Air Pump, Figs. 12 and 15—As may be seen from the curves on Fig. 12, the water rate is about the same per dynamometer horsepower per hour for the two series *E* and *F*. The fuel consumption per dynamometer horsepower per hour is 7 per cent. better for the series *F* when the heater, fan, condenser and air pump were used.

(f) Ratio of Dynamometer Horsepower to Rated Horsepower of the Engine—The rated horsepower of the engine was 30 and five tests were made to determine the maximum horsepower which could be maintained for five minutes at the dynamometer. The three tests on the old engine, No. 1, gave 41.7, 42.3 and 43.7 dynamometer horsepower on three different days. This showed that the engine was capable of an overload at the drivers of 39 to 45 per cent. Similar tests were made on the new engine, No. 2, the first day it was installed which gave 41.7 dynamometer horsepower or an overload of 39 per cent. The pounds of water per dynamometer horsepower per hour was 12.98 for this test, while the boiler efficiency was 64 per cent.

Some Tests of Jessop Ark High-speed Steel

Some interesting results were recently obtained by Wm. Jessop & Sons in testing out their "Ark" high-speed steel, which was worked in tools 1½x3 inches.

In some tests which were conducted at the Otis Steel Company a cut was taken, on a planer, from an 0.80 per cent. carbon steel which was hammered into shear blades. The shear blade was 6 inches wide and 8½ feet long, and the tool took an entire cut across it without being ground. The tool was given a 1/16-inch depth of cut, ⅛-inch feed and a travel of 16 feet per minute.

The second test was in turning a 1 per cent. carbon cast-steel roll, in which the first cut had a depth of 1⅜ inches and a feed of 1/16 inch, while running at 10 feet per minute. At this speed it took 4½ hours to finish a cut across the roll. The second cut was ⅞ inch deep, with a 1/16 inch feed, and the same speed, namely 10 feet per minute. As it also took 4½ hours to make this cut, and both cuts were made without taking the tool out of the tool post, it means that the tool was run 9 hours steady without grinding.

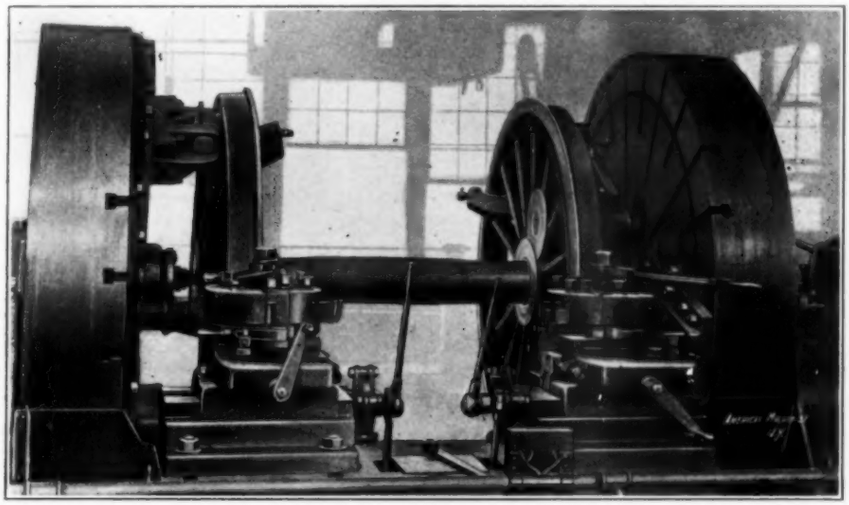
A third test was in turning cast-steel rolling mill pinion that contained 0.48 per cent. of carbon. On these the cut was 1¼ inches deep, with a 1/16-inch feed, and a speed of 12 feet per minute. The tool on this work worked 20 hours without regrinding and was still in good condition at the finish. On a chill roll a tool 1½x 2½ inches worked 18 hours without grinding.

At another place a series of tests were conducted on locomotive tires. These tests consisted of turning the rims of the tires on a Niles-Bement-Pond Company's 90-inch tire lathe, and the results of the tests are given in tabulated form in the accompanying table. No comment on this is necessary as the table shows for itself what was done. The lathe with the tires set up in it is shown in the illustration and will show that the work was performed in the ordinary way.

Test No.	Diameter of Tire in Inches.	Make of Tire.	Speed in Feet per Minute.	Feed in Inches.	Depth of Cut in Inches.	Time Cutting in Minutes.	Condition of Tool.	Work on Tool to Put in Service.	Remarks.
1	63	Midvale	15	1/16	7/16	12	Failed	Ground.	Cut 3¼ over tread, finished with shop tool; very hard tires.
2	62¾	Midvale	15½	1/16	1/16	22	Fair	Ground at finish.	Slowed to 12½ feet; 3¼ inches over tread.
3	63	Midvale	12½	1/16	7/16	23	Good	None.	Tire very hard.
4	62¾	Midvale	12½	1/16	1/16	24	Fair	Ground.	
5 1st cut	78¾	No mark	10	1/16	11/16	28	Good	None.	
2d cut.			12	1/16	1/16	22	Good	None.	
6 1st cut	78¼	No mark	11½	1/16	11/16	25½	Good	None.	Tire very hard.
2d cut.			11½	1/16	1/16	25	Fair	Ground.	
7	62¼	No mark	16½	1/16	11/16	20½	Good	None.	
8	62¼	No mark	16½	1/16	1/16	20	Fair	Ground.	
9	62¼	No mark	16½	1/16	11/16	19	Good	None.	
10	62¼	No mark	17½	1/16	1/16	19½	Good	None.	

Total weight of chips removed, 1133½ pounds. Size of tool, 1½ by 3 inches.

TESTS OF JESSOP'S ARK STEEL IN TURNING LOCOMOTIVE TIRES ON NILES-BEMENT-POND CO'S 90-INCH LATHE.



NILES-BEMENT-POND COMPANY 90-INCH TIRE LATHE AS USED FOR TESTS OF JESSOP'S "ARK" HIGH-SPEED STEEL

Low Coal Consumption of Combined Reciprocating and Turbine Engines

The "Laurentic," the new White Star liner for the Canadian trade, recently ran her trial trip at Belfast, Ireland. Her engine equipment consists of two four-cylinder triple-expansion engines working on the outboard propellers and one low-pressure Parsons turbine connected to the amidships propeller, the combined power of the engines being 10,000 horsepower. The boiler pressure is 200 pounds per square inch, and the steam leaves the low-pressure cylinders of the reciprocating engines at from 14 to 17 pounds per square inch. From the low-pressure cylinders it goes direct to the turbine on the center shaft, but for maneuvering the ship into and out of the port, the turbine is cut out and the steam is led directly to the main condensers from the low-pressure cylinders of the two triple-expansion engines. The levers for operating the maneuvering valves are alongside of the handles for operating the starting gear. On the trial trip, the engines developed 2000 horsepower more than was expected from them. The power of the turbine engine was measured by torsion meters. One torsion meter was attached to each of the tunnel shafts. Indicators were used on the reciprocating engines and the readings from the cards were compared with the readings from the torsion meters and showed only 1 per cent. difference. From this it was assumed that the torsion meter on the central shaft, that being the one to which the turbine is connected, was correct. The consumption was very low, being only 1.1 pounds per indicated horsepower per hour. The water consumption was also low being only 11 pounds per indicated horsepower per hour, showing high boiler efficiency. The "Laurentic" was guaranteed to give a speed of 15 knots and this was exceeded by 2½ knots, as on the trial trip she did 17½.

Learn to Do The Difficult Things

In nine cases out of ten a man's life will not be a success if he does not bear burdens in his childhood. If the fondness or the vanity of father or mother has kept him from hard work; if another always helped him out at the end of his row; if what was light fell to him and what was heavy about the work to someone else; if he had been permitted to shirk until shirking has become a habit—unless a miracle has been wrought his life will be a failure, and the blame will not be half so much his, as that of his weak and foolish parents.

On the other hand, if a boy has been brought up to do his part, never allowed to shirk responsibility or to dodge work, whether or not it made his head ache, or soiled his hands, until bearing burdens has become a matter of pride, the heavy end of the wood his choice, parents, as they bid him goodby, may dismiss their fear. The elements of success are his, and at some time and in some way the world will recognize his capacity.

Waste of Resources Due to Fire*

By Charles Whiting Baker†

The topic assigned to me this evening is in more senses than one a "burning" subject. I know that statistics are apt to be dry, and statistics of fires naturally would be dry anyway. But I have to ask your attention to a few statistics of the waste due to fires.

The United States Geological Survey has been for some time engaged on an investigation of the losses by fire in the United States. Through the courtesy of Herbert M. Wilson, of the Survey, I am able to give you some of the main results of this investigation which have not yet been published.

The sum total of the losses by fire in the United States in the year 1907 was $215,000,000. About half of this $215,000,000 was loss upon the buildings themselves which were burned or injured by fire. The other half was upon the furniture, merchandise, etc., contained in the buildings. Besides this vast property loss there were 1450 persons who lost their lives in fires and 5650 were injured. The fires which caused these losses of life and property occurred in 165,250 buildings and the average damage to each building and its contents was $1667.

Notice that these are the direct losses only. No estimate has been made of the indirect cost of fires, the interruption to business, the expense of maintaining fire departments and of conducting fire insurance companies which distribute the loss generally over the community. Also, these figures include damages to buildings and their contents only. There are, besides, the damage done by fires in mines and in forests to be taken into account to obtain the full record of destruction due to this element.

Let us come back, however, to these figures of total loss by fires in buildings in 1907. What do these figures mean? Do we really comprehend their significance? We speak glibly of a million, or a hundred million, or two hundred million, but do these figures really create a vivid picture in our minds?

I strongly suspect that we, as engineers, too often handle statistics and numbers and records without clearly comprehending how much—or how little—they mean. We handle them quite as the engineering student sometimes handles his problems in algebra or mechanics—X and Y and C are just letters to him. He forgets that they symbolize actual concrete quantities. So we forget in dealing with large figures to visualize the bulk they represent.

Suppose we try to picture to ourselves what these many millions of dollars worth of valuable buildings in which fire annually rages would look like. Suppose it were possible to bring these buildings which were visited by fire in 1907 all together and to range them on both sides of a long city street. Let us place these buildings closely together as they might be placed on an ordinary street in a fair sized city. We will assume that the lots on which these buildings stand have an average frontage of 65 feet. How long a street do you suppose would be required to make room for all these buildings? Make a mental guess in your mind before I tell you and you will then have some idea how accurate your conception of large numbers is. Perhaps you may guess that such a street would reach the length of Manhattan island; or you may be bolder and guess that it would reach from New York all the way across New Jersey to Philadelphia. But those of you who are apt in that most useful branch of mathematics to the engineer—mental arithmetic—have perceived already, I doubt not, that the street will be far longer than this. I may say at once that this street, lined on both sides with the buildings visited by fire in 1907 would reach all the way from New York to Chicago.

That is what the annual fire loss of the United States represents—a closely built-up street 1000 miles long, with every structure in it ravaged by the destructive element. Picture to yourself driving along this terribly desolated street. At every 1000 feet you pass the ruins of a building from which an injured person was rescued. Every ¼ mile there is the blackened wreck of a house in which someone was burned to death.

Imagine this street before the fire touched it, lined with houses, stores, factories, barns, schools, churches. Suppose the fire starts at one end of the street on the first day of January and is steadily driven forward by a high wind, just as actually happens in a conflagration. Building after building takes fire; and while the fire fighters save some in a more or less injured condition, the fire steadily eats its way forward at the rate of nearly three miles per day, for a whole week, for a whole month, for all the 12 months of the year. And at the end of 1907 did the conflagration end? No; it began on a new street 1000 miles long which was likewise destroyed when 1908 was ended. And this same destruction is going on today.

But you say, do not the figures you have quoted represent an unusually bad year? And are not the improvements in construction, the better building laws, the better fire protection, showing in diminished fire losses? Unfortunately I have to answer no to both these questions. The statistics of fire losses gathered for many years by the National Board of Fire Underwriters show that the annual fire loss has been steadily increasing. In the 10 years ending with 1907 the annual fire loss averaged $203,000,000. In the 10 years ending with 1897 it was $132,000,000. In the 10 years ending with 1887 it was $92,000,000. Thus our fire loss has doubled in 20 years. Of course, the increase in population, in wealth, in number of buildings, means that more property and lives are at risk from fires and accounts for the increase in total fire losses that the past 30 years has shown. But that increase has not been noticeably checked by anything which we have done to reduce the fire risk.

But again you say, is not this fire loss a necessary evil? Must not a certain risk of fire be incurred in any building? Is there anything to show that the total fire loss, the risk to property and to life can be reduced?

These are fair questions and their answer may lead us to take what I may call a common-sense view of the subject. A certain amount of loss by fire must be expected. Safety and danger are relative terms, and there is no such thing as absolute safety. But we have only to look at the records of fires in European countries to learn that our fire losses are very, very far beyond those of any other country of advanced civilization. The fire loss in the United States in 1907 represented an annual per capita tax of $2.50 on every man, woman and child in the population. That means a tax of $15 per year on the head of every family of six persons. In the principal European countries the fire loss per capita per annum is as follows: Italy, 12 cents; France, 30 cents; Austria, 29 cents; Germany, 49 cents. Allowing for the fact that European populations are far more dense than our own, it is yet evident that their losses are only a small fraction of those in the United States. It is only in Russia and Norway, where wooden buildings form a considerable proportion of the whole that the fire loss per capita approaches even half of our own per capita rate.

I have referred to a common-sense way to treat this question of fire risk. It seems to me that the common-sense way is to reduce fire risk by better construction whenever and wherever it will pay to do so. The engineer's business is to make a dollar earn the most interest. If a structure will represent a smaller annual cost for its whole life, insurance and fire risk taken into account, when built of wood than when built of iron, or brick, or stone, or concrete, then and there wood is the material to use. Deplore as we may the loss of the forests, the engineer, like everyone else, is hemmed in by economic laws and market prices and cannot stray far from the bounds that they set or he will find his occupation gone.

But—this is a big but—the trouble is that the public—and the engineers with it—is apt to run on in a rut. We go on building in the old-fashioned way because it *was* the cheapest once and are not wise enough to realize the economy of newer methods. Nothing but high and higher prices for lumber will bring us to our

*Address at the union conservation meeting of the engineering societies.
†Editor, *Engineering News*.

senses and induce us to wake up and bring ourselves and our practice up to date.

I said, you remember, use better construction whenever and wherever it will pay to do so. I use that word "pay" in a very broad sense. It may pay the builder or the owner best to put up a cheap building, which will be a danger to tenants and a menace to all adjacent buildings. A hundred or a thousand such buildings huddled in a city make the possibility of a conflagration. Thus comes about the necessity of laws to regulate building. We have erred in the past and still err all over this broad land, because we have laid over-much emphasis on the right of each individual to do as he pleased with his own. And we have been slow to realize that this liberty often degenerates into license to do as he pleased with the rights and the property of his neighbors.

I do not overstate the case when I say that our American cities and villages are made up almost wholly of fire-trap buildings. We have lagged far behind in our adoption of better and safer methods of building construction. We must for at least a generation to come pay the penalty of heavy charges for fire protection, heavy insurance rates, heavy fire losses. And we must continue to bear this heavy tax until we rebuild our cities with fire-resisting structures.

Fortunately the engineer has provided the means and the materials by which better and more economical construction can be substituted. It was the circular saw and the railway that created cheap timber throughout the nineteenth century and housed the people of the United States in cheaply built and easily burned wooden buildings. It is the rotary kiln for burning portland cement, the rock drill, the brick press and 1000 other modern inventions that are to create the incombustible buildings which the twentieth century is to construct.

Let us not forget, either, that incombustible buildings are only one part of the art of fire-protection engineering. Most of the materials of commerce are combustible. Many are highly inflammable. We must protect the contents of warehouses and factories, even though the structure be safe.

I know of no better proof of the possibilities in the field of fire prevention than what has been actually accomplished by the factory mutual insurance companies of New England. These companies, insuring chiefly mills which handle cotton, one of the most inflammable of materials, have reduced their rate of loss to about 5 cents per annum per $100 insured, a rate of loss little more than a tenth, probably, of the average fire loss on all classes of buildings in the United States. I cannot refrain from saying that among the pioneers who have done most in accomplishing this feat in conservation—in the prevention of waste—is the first speaker of this evening—John R. Freeman.

The automatic sprinkler, the automatic fire alarm and many other devices, with the organization and discipline of fire-fighting forces, and inspection for fire prevention, have transformed one of the most dangerous classes of fire risks to one of the safest.

My sermon on this burning question must draw to a close, but I must say just a word under my second head, which is forest fires. I will not bore you with many statistics of forest-fire losses. Surely, surely the memory of the forest fires which raged last September and October and of the vast losses of property and the terrible losses of life that then occurred is too near and too vivid to need more than a passing allusion.

The fires which raged in the Adirondack region last fall burned over an area of 347,000 acres, or 542 square miles. About 38 per cent. of this area bore merchantable timber. This damage was done within the limits of one single State. I leave you to form your own estimate of the value destroyed by these fires and by the multitude of other fires which raged through New England, in Pennsylvania, in the pine forests of Wisconsin and Michigan and Minnesota and the Southern States.

And the worst result of the forest fire—even worse than the destruction of valuable timber and young, growing trees which should furnish the lumber that will be so sorely needed a quarter of a century hence—is the destruction of the soil itself. There are many hundreds of square miles in the Adirondack regions where forest fires have burned away the wood soil and humus and have destroyed the possibility of reproducing the forest growth—at least for long years to come. Is it a light thing that these vast areas, which might under proper administration go on producing year after year a steady crop of timber, should be reduced to barren desert?

What I most want to make clear to you is that unless and until you create in every forest State of the Union effective laws and effective organizations to prevent forest fires—unless and until you do that thing—all our talk of conserving the forests is vain. We cannot get away from economic laws. We cannot expect a man to preserve valuable woodlands uncut when a forest fire may at any time wipe out the property entirely. And the higher the price of lumber goes, the greater the inducement to cut off the trees.

Thus the more our forest dwindles and the nearer the inevitable timber famine approaches the more certain we make it that all the forests shall disappear. If a man could hold his timberlands like other property for a higher price without risk of total loss, many would prefer to do this and many would be found to undertake timber culture; but so long as timber properties are subject to grave risk of total loss, they cannot be attractive to capital.

Someone may criticize that I have said very little so far about conservation. But surely little need be said to prove that the fire loss is a waste and a vast drain upon our natural resources. Everyone appreciates it, of course, where forest fires are concerned; but it is just as much of a drain on the forests to burn up the boards and the timber in a house which must be rebuilt as to burn up the trees before they are cut down and sawed. And not only timber, but iron, tin, lead, zinc—all the materials used in building construction and a vast amount of merchandise contained in buildings is devoured annually by the flames. Surely, then, the prevention of this waste, the work of the structural engineer and the fire-protection engineer, is a task whose accomplishment means much for the public benefit, means much for the conservation of the world's resources.

Needle Making Extraordinary

By P. J. Hearne

The following description of the process of making needles is very interesting:

"In the making of needles a coil of fine steel wire is first run into an elaborate machine and cut into pieces the length of two needles. These lengths are gathered into little bundles, and each end of the wire is sharpened at the rate of hundreds a minute by being pressed against a grindstone, the sparks, flying in a continuous stream, making a miniature firework display. Two eyes are next stamped in the center of the wire, which is then broken in half, forming two needles, and roughly 'first finished' by having the burs rubbed down.

"At this stage the needles are still soft wire and need hardening, so they are soaked in a bath of hot oil and when cool again are quite hard and brittle. Then follows the polishing process, when, done up in bundles of thousands, the needles are continually rolled in sand for a period of seven days, coming forth from the process with a fine polish.

"Lastly they are threaded on wires, and a little friction makes the eyes bright and clear before they are taken to the packing room.—*Pearson's Weekly.*"

Readers of the American Machinist would, no doubt, be glad to have a detailed description of "the *elaborate* machine" for cutting off, and the method of sharpening them "in bundles" must be remarkable.

The hardening, by simply "soaking in a bath of hot oil" is very simple indeed, although I regret to see that this leaves the needles "hard and brittle."

The polishing process, "in *bundles* of thousands, rolling in sand for seven days," must certainly produce a fine polish. I wonder what kind of wire is used for polishing the eyes. Is it any wonder that the public are credulous when our magazines disseminate such rubbish, as technical information?

Practical Letters from Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

Machining Small Bearings

Many methods have been devised from time to time for machining small bearings of the type shown in Fig. 1, but that in which a half mandrel is used is not very frequently met with, although in many instances, more expeditious results can be obtained than by some of the methods in vogue. Such a bearing, if it is to be produced in quantities, calls for equipment which, by reason of its simplicity, will enable maximum output to be combined with close limits of error, while at the same time keeping labor costs low.

In giving the sequence of operations by this method a description of the various fixtures, etc., will be embodied, thus enabling references to be readily traced. The bearings here dealt with are of phosphor bronze and lined with white bearing metal.

Operation 1: Disk grind the joint face, removing sufficient metal to enable the outside diameter to be cleaned up in turning.

Operation 2: Chuck the two half bearings in a two-jaw chuck on the capstan lathe, rough bore, form the recess for retaining the metal, rough turn the outside diameter as far as possible. Re-chuck and complete rough turning. This operation will be fairly obvious; the castings are bored roughly, thus giving the bearing metal a better grip. The angular surfaces are formed with a tool of the usual type.

Operation 3: Spot for two holes in each half bearing. A tin templet is provided for marking off the metal retaining holes, a piece of tin being cut and bent to fit the recess, from which the holes are very quickly marked.

Operation 4: Use a flat bottoming drill, in the sensitive driller and drill holes to depth for the metal. An ordinary twist drill ground off square will be quite satisfactory in this operation for small bearings, but for the heavier types it is better to start the hole in the ordinary way, using the flat-bottomed drill to finish out.

Operation 5: Run in white metal. No attempt will be made at describing any "best" methods for doing this, most people holding their own opinion as to what gives the most favorable results.

Operation 6: Clean off metal on the disk grinder back to the joint faces.

Operation 7: True joint faces to surface if required. This is usually found necessary owing to the disk tending toward a more or less hollow finish; why this is so, is not quite clear, but may be due to the flimsy hold on the bearing.

Operation 8: Mount the work on a half mandrel, turn the ends as far as possible in the engine lathe, say 0.025 inch above finished size. The half mandrel Fig. 2, made from machine steel, has the two ends *A* turned down to any convenient size to clear the center part *B* which is first ground accurately to the finished size of the bearings. One-half of this center portion is then cut away as shown, sufficient being left to enable the two faces to be scraped perfectly true.

This latter point is important as the amount by which the mandrel varies from a true half circle, will be duplicated in the opposite direction on all bearings turned on it. In other words, if the mandrel exceeds a half circle, the bearings will be short of the half circle by the same amount and *vice versa*. The length of the center portion is immaterial, so long as sufficient support is given the bearings. Having placed a half bearing in position on the mandrel, the clip, Fig. 3, is fastened round the center, just tight enough to prevent movement; if fixed too tightly, the bearing may be distorted. The ends are then turned as far as the clip. It will be seen from a subsequent operation, that whatever amount of metal is determined upon as suitable to leave at this operation for finishing, it must be rigidly observed as a standard for the whole, a variation of even 0.0003 inch being sufficient to affect the final accuracy.

Operation 9: Use the special fixture, Fig. 4, bolted to the face plate of the capstan lathe, and finish bore to gage, face the end and form the round corner at the end of the bore. Reverse the bearing, face the end to length, and finish the 0.25 radius at the other end of the bore. The fixture consists of a cast-iron body *A* having a boss *B* turned to suit a recess in the face-plate, to which it is secured

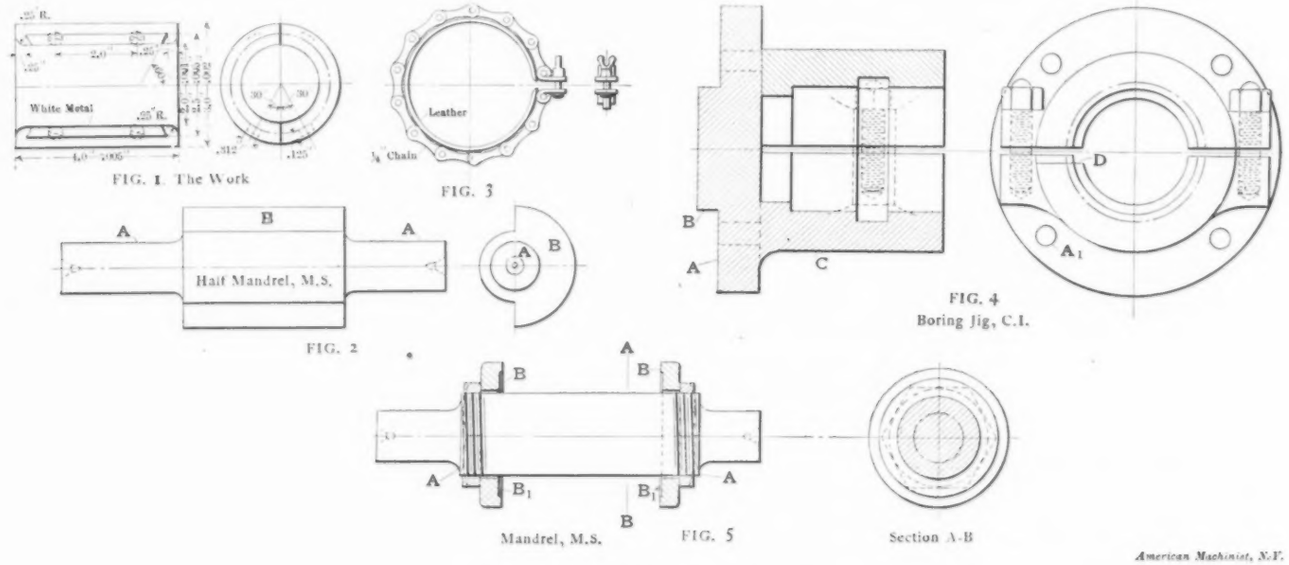


FIG. 1. The Work

FIG. 3

FIG. 2

FIG. 4
Boring Jig, C.I.

FIG. 5

TOOLS FOR MACHINING SMALL BEARINGS

by four bolts at A'. The bearing carrier C (cast integral) together with its cap, is bored to receive the bearings as left by operation 8. The bore is recessed as shown, to clear the rough turned part of the bearing diameter, but should not be wider than necessary, as undue clearance lessens the support for the bearing. A small portion at the back of the bore is cut away at D to enable the micrometer head to be inserted when facing to length. The bearings should in all cases be relieved by slacking back the cap before taking a finishing cut.

Operation 10: Bed the work to the mandrel if necessary. This operation should not be necessary if due care is taken in boring, so that the bearings are not distorted or sprung by tight clamping. The operation covers, however, a detail of importance if the accuracy is not to be marred, viz., renewal of the joint face.

This is generally considered negligible, but is a frequent cause of more or less mysterious inaccuracies. In boring, or turning any bearing in two halves, a bur proportionate to the pressure exerted in the operation, is forced up between the joint faces and in the case of a light bearing, is so small as to be practically undiscernible, but it is none the less there. In using the half mandrel then, it becomes important to make quite sure these burs are removed before finish turning.

Operation 11: Hold the work in the engine lathe on a special mandrel, Fig. 5, turn to finish size as far as possible, clip by the center, remove the end cups and finish turn the ends.

The mandrel shown is solid, ground to suit the finished bore of the bearings, and threaded at each end to receive the locking nuts at A. Clamp disks B, of hardened steel, are bored to clear the mandrel and have a recess B' ground to suit the bearings as left by operation 8.

These recesses should be as shallow as possible, say, 0.025 inch, a grip on the bearing being all that is required. After turning the outside diameter to size as far as possible the clip used in operation 8 is fixed around the center to retain the bearing in position and the end nuts and clamp disks removed; the two small end shoulders are then removed.

This method of dealing with bearings may appear at first sight somewhat long, or to entail abnormal care in order to attain precision; no difficulty, however, is met beyond that common to any other method, and the work is performed at minimum cost, while employing no elaborate machines.

H. PEARMAN.

Basingstoke, England.

Splash Lubrication

In a gear box designed to be entirely splash-lubricated, it was found that several of the bearings gave trouble by heating, due to imperfect lubrication, although when the inspection covers were removed, judging by the quantity of spray or splash, one could hardly imagine any point which could not be reached by the splash, if not directly at least on the rebound of oil impinging upon the moving parts, or even upon the walls of the box. Indeed, several natural openings through which the gear-changing mechanism passed, had to be provided with deflectors to intercept and prevent its emission.

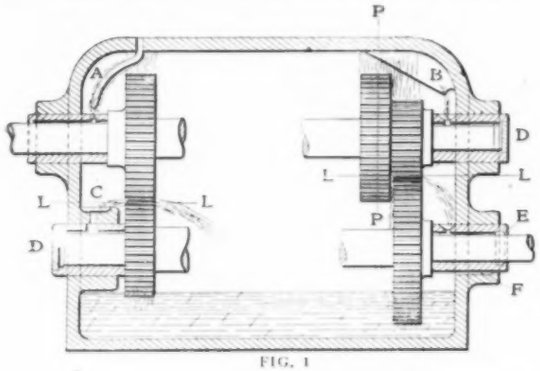


FIG. 1

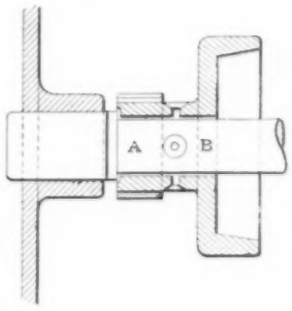


FIG. 2

American Machinist, N.Y.

SPLASH LUBRICATION

Failing to locate the cause of the trouble by inspection of the actual mechanism running, the box was stripped. Examination showed that the walls and parts of the bore contiguous to the troublesome bearings were practically dry. The drawings were brought into the discussion and it was found that these particular parts were so placed that they lay outside the planes of rotating gears, and also above the lines passing through intermeshing teeth-lines P and L, respectively, in Fig. 1. Splash mainly arises in two ways: (a) by centrifugal force, from the faces and edges of rotating parts; (b) by the squeezing action of the teeth causing the oil to fly axially. This is clearly shown in Fig. 1. Bearings directly on these planes or lines of flight are hence well cared for; elsewhere other means must be provided for conducting the oil to points where needed. Fig. 1 shows several methods of dealing with such cases. At A is shown how a wire conducts the oil from a point inside the plane of splash to the bearing. At B is shown how a stalactite-like projection cast on the roof of the box, and at C how a groove cast in a boss, serve the required purposes.

Perhaps these little things appear obvious to many designers, but a detailed examination of several gear boxes on the market shows that similar difficulties have been overcome by the provision of supplementary oiling devices, and even ordinary oil holes surmounted by the usual oil hole cover. In my opinion this savors of meanness. Then consider what beautiful talking points the salesmen have in such phrases as "automatic lubrication" "needs oiling only once a year," and so on.

Here is another lubrication trouble leading, perhaps, to an interesting speculation as to how much labor is being wasted in providing means of lubrication where perfectly automatic means already exist.

Certain clutches and other parts which had periodic rotation independent from their shafts were provided with four equi-spaced oil holes having large countersinks. Four holes were provided so that during periods of rest, at least one hole would be vertical or nearly so, and so allow oil, which had collected during running periods to run in. That these holes served this purpose admits of no denial, but in one case the purpose was served by no means efficiently, as was eventually proved by a clutch seizing. Examination revealed the fact that the left-hand end A of the clutch, Fig. 2, had run practically dry. The bearing at the same end was one of those previously mentioned as having given trouble, but not up to this moment discovered. The right-hand part B of the hole as far as the oil holes was in good order, which seemed to prove that oil had been admitted at the right-hand end and having traveled as far as the radial oil holes, was thrown out before it had time to work its way forward to the left-hand end. Had the left-hand bearing been freely lubricated, no doubt no trouble would have been experienced and we should never have discovered how to make money by saving the labor we now save in dispensing with those oil holes.

It was pretty obvious that, the hole having received perfect lubrication from the one end, up to a certain point, by omitting the leaking points we should probably get the oil to creep the rest of the way. Plugging the radial oil holes and running again for a test proved our assumption to be correct. And today it has become our general practice in splash-lubricated mechanism, not only to omit the external oil holes, but also the internal oil grooves; perhaps every mechanic has been struck by the fact that in machines which have run for any length of time, all oil grooves have become entirely choked with a solid, probably consisting of worn-off metal and gum from the oil. For safety, however, we have adopted a slightly freer running

fit, making a 1½-inch shaft, say, about 0.003 inch smaller than the hole, and varying this allowance with the diameter and length of bearing.

The explanation of the matter is this: The oil, falling, clings to the surfaces and flows by capillarity between the surfaces and it would probably be more remarkable if it failed to flow, in view of this natural law.

All our troubles were, however, not surmounted when free lubrication had been assured. In fact, in some cases lubrication was much too free to please, for oil leaked rapidly through the bearings. This trouble was cured in most instances by closing up two ends of the bearing bushes, as shown at *D*, Fig. 1, but in the case of the driven shaft or power offtake shaft, the difficulty was overcome by turning a groove *E* around the hole, as shown, and drilling a hole *F* to conduct the oil back to the reservoir.

Sheffield, Eng. ROTOR.

Milling on a Boring Mill

We had to make between 3000 and 4000 per week and mill the top surface as shown in Fig. 1. The price was close, about ⅓ cent per piece, and the milling must be within 0.002 or 0.003 inch of level. We could not consider any time lost for chucking, and did not think it necessary to take two cuts, thus the problem of a continuous milling and chucking operation.

We had a boring mill that had seen some service, the speed of which we reduced to about 1 foot per minute. We then took off the tool block and bolted an Adams milling head to the vertical slide, locating the spindle vertically, and equipping it with an inserted-blade end mill. We made a set of the jigs, Fig. 2, making eight jigs to the table and bolting four pieces of the work to each jig; 32 pieces to the circle.

FIG. 1

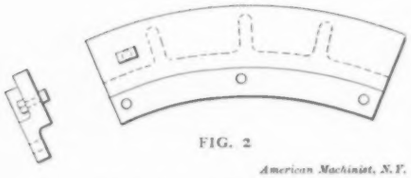


FIG. 2

American Machinist, N.Y.

THE WORK AND THE JIG

An operator would stand at the front of the machine and take off and put on one piece every half minute. The peripheral speed of the cutter is 138 feet per minute, and we are cutting about 1 /16 inch off the casting. A cutter holds up from 55 to 60 hours to a grinding, and we are looking for a high-speed steel that will permit us to do better.

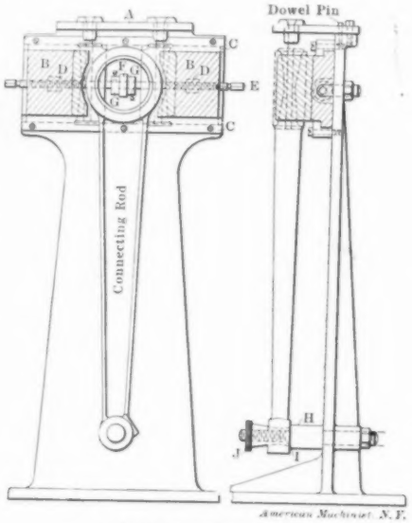
Erie, Penn. A. H. STEEL.

A Connecting Rod Jig

In the accompanying sketch is shown a jig for holding a gasolene-engine connecting rod during the operation of drilling the stud-bolt holes in the crank end. These holes must be equidistant from the center of forging, also in the center of the stud lugs.

The connecting rod is a steel drop forging of the web-and-rib type. The ends are solid with the exception of the holes being forged in allowing just stock enough to machine. Not all forgings are correct, and this jig is designed to take care of such irregularities as may occur in the forgings and to turn out correctly finished connecting rods.

The stand is cast iron, machined at the bottom, and finished at the top to receive bushing plate *A*, also on the face to receive sliding jaws *B* and guides *C*.



A CONNECTING ROD JIG

The cast-iron plate *A* is secured in place with cap screws and dowels and carries case-hardened machine-steel bushings for the drills. The cast-iron jaws *B* have depressions in their faces corresponding to the portions of the rod end which they grip. *D D* are brass nuts tapped right- and left-hand for the threaded portion of shaft *E*, which is provided with square ends to receive a wrench for operating jaws *B*. At *F* is secured a forging having a hole bored through for the feed screw and secured to the feed screw with set screws are two collars *G*, one at either side of *F*.

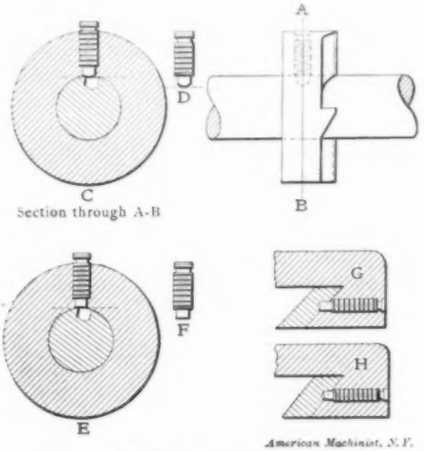
At *H* is a machine-steel shoulder bolt which is not intended as a clamp bolt, but rather as a gage; any spring in the forging will show at shoulder *I*, and this is corrected before any machining is done. The conical nut *J* is set up by hand and the purpose of this is to bring each forging in the same position in relation to the clamping jaws *B B*.

The balance of the machining on the rod is gaged by these two stud-bolt holes, after which the crank end is milled through the center.

Detroit, Mich. R. D. T.

Should Pilot Screws be Made Flat on the End

It seems to be the practice of makers of screws to make the pilot screws with a flat end, as shown at *F*, with corners as sharp as a knife. As I believe it far more sensible to make them with beveled ends, as shown at *D*, I will try to point out why.



FLAT- AND BEVEL-END PILOT SCREWS

For illustration, I have chosen a bar with a facing cutter and a pilot screw for holding the cutter in its place. It will be seen at *E* that if the screw has a flat end and the locating hole is a little off to one side while screwing down the screw, the corner of the screw will cut down the side of the hole. But as shown at *C*, the angle on the end of the screw will pull the cutter around until it comes in line, and then the screw will enter the hole without injuring the sides.

Considering the way the screw strikes the bottom of the hole I should also prefer the one shown at *C* and *D*. It may be said that these screws are often used for gibs, and there is often little room to drill very deep for the end of the screw.

Let us, therefore, look at *G* and *H*, one showing a screw with a flat end, the other one with a beveled end. It will be seen that while the hole in the gib cannot be very deep we have always a bevel on the bottom of the hole left by the drill and, therefore, the screw shown at *G* enters just as far as the one at *H* with the flat end.

The bevel should be about the same as the angle on the lips of a drill, i.e., 118 degrees. I hope this will be read by screwmakers, and if it is their practice to make them with a flat end, it would be interesting to hear their reasons.

Cleveland, Ohio. A. NIELSEN.

Truing the Top of a Drill Press Table on a Planer

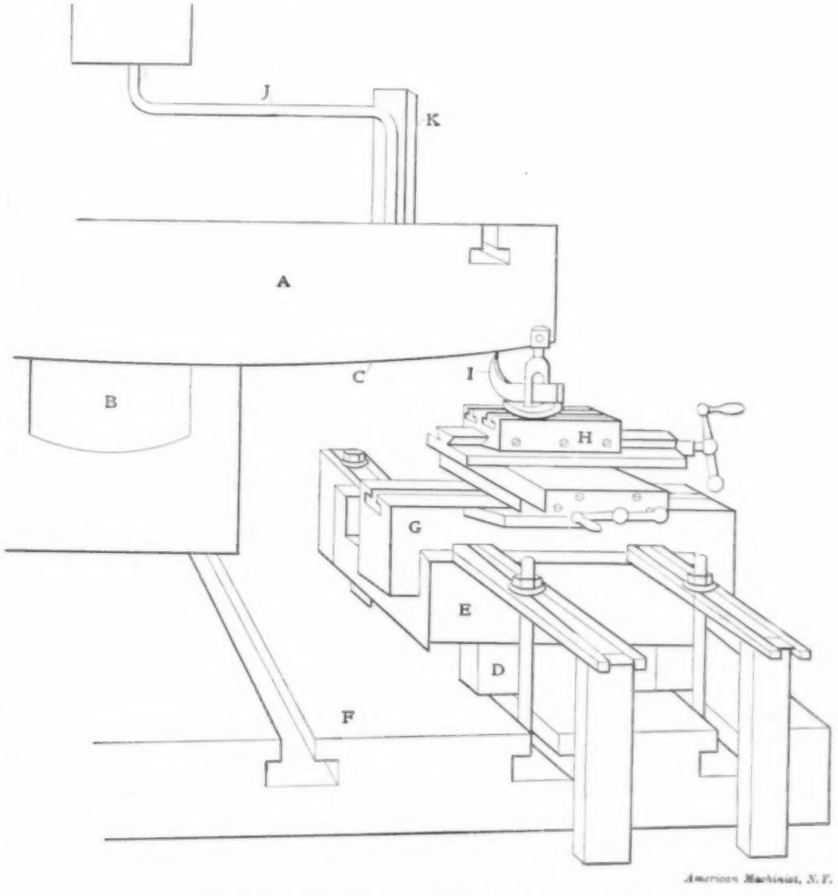
The other day we wanted to square off the top of a drill table *A*, about 2 feet in diameter. As there was no lathe in the shop large enough to do it, the planer hand was told to do it on the planer. As the table *A* did not turn true in its bearing *B* he proceeded to true the bottom edge of the flange off at *C*, so he would have a true surface to clamp down on the planer.

He took four blocks *D* and placed them on the base *F* of the upright drill. On top of these blocks he placed a planer vise *E*, clamping it down by bolts in the T-slots of the drill base. A short section *G* of a bench-lathe bed was found and clamped in the vise *E* at just the right hight to take a bench-lathe slide rest *H*, which was bolted down through the lathe bed in the usual way. A rather nondescript tool *I* was made to go in the tool post.

The table was turned by means of an iron rod *J* connecting it with the drill spindle. This rod was held in the drill chuck and bent at right angles with another right-angle bend down into a slot in the table, where it was wedged with a piece of wood *K*. The bearing of the table was well oiled and then on the slow speed a light cut trued the bottom of the rim. After that, finishing the job on the planer was easy.

ARTHUR N. KING.

Waltham, Mass.



HOW THE JOB WAS PREPARED FOR THE PLANER

Locating Centers in Rough Forgings

This method of locating centers in forgings first came to my notice in 1892, and was suggested by W. H. Sylvester, general foreman for the Southwark Foundry and Machine Company, Philadelphia, Penn. As it is the simplest and most convenient method I have ever seen and does not seem to be generally known, it may be of use to some of your readers and of interest to others. All that is necessary is to secure two light and slightly flexible strips of wood and fasten them together temporarily (while cutting slots), then cut a center slot in them vertically like *A*, Fig. 1, and locating from that slot saw equidistant narrow slots both ways from the center to the ends, preferably 1 inch apart and numbered as shown. Now place one of these strips on each end of the piece to be centered and drop a fine

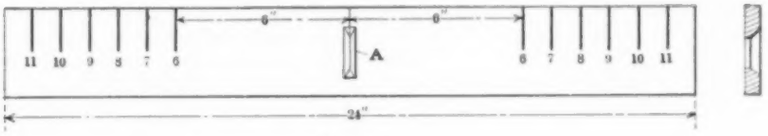


FIG. 1

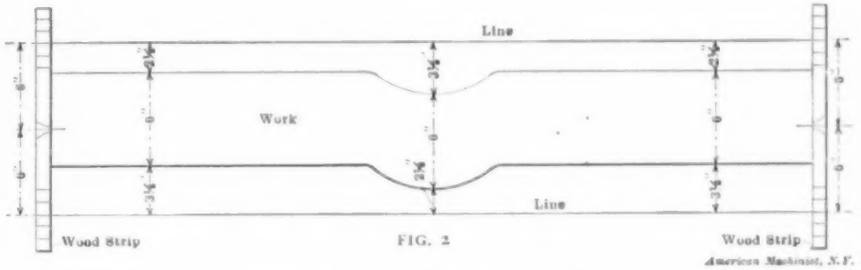


FIG. 2

LOCATING CENTERS IN ROUGH FORGINGS

line in corresponding slots in both sides of the work pulling the line tight to hold the strips in place and measure from the line to any depression or projection as in Fig. 2. When all the high and low spots have been located and their distances from the lines made equal or averaged by moving the strips carrying the lines across the end of the work, scribe a line on the work through the center slot *A*, Fig. 1. Then move the strips around 90 degrees and proceed as before. In the case shown in Fig. 2, by moving the lines and averaging distances, it will be seen that 3½ inches is the greatest distance from the line to the shaft on opposite sides which subtracted from 6 inches, the distance from the line to the center, gives 2½ inches, or 5 inches as the diameter of the largest piece it is possible to obtain. The intersection of the lines scribed is the location of the center to be drilled, and there is no doubt as to whether the work will true up to the size required. This method is useful particularly on work too heavy to revolve on temporary centers. It is a very convenient arrangement for ascertaining whether a crank-pin or eccentric can be trued up on the forging before commencing work in the lathe. When the center is laid out from the ends of the work as is customary, there is no assurance as to whether there is enough stock to true up in the middle of the piece or not.

Elizabeth, N. J. D. W. BARTON.

Discussion of the Previous Question

Letters from Our Readers Showing How Many Men of Many Minds Look upon Various Subjects Opened up in Previous Numbers

WE PAY FOR THESE ALSO

Down with the Standard Involute Gear Tooth!

Mr. Grant got after the right thing, but the wrong end of it, at page 582. The real trouble is that Brown & Sharpe ought not to have standardized gear teeth until the last word had been said on that subject. Then, again, possibly it was Mr. Grant's fault, anyway. Why did he not bring forth this sinusoidal tooth before Brown & Sharpe got their involute tooth on the market? As usual, the man who kicks is the one at fault. The chief trouble with this world is that it is progressing.

Mrs. Entropy gets after me every little while. I like to carpenter around, as I believe I have said before. As a preliminary to a job of any size I usually build a staging. She always objects; says I ought to spend my time making useful things, not just doing something that I am going to knock down. I have tried to persuade her that, being only a man, I cannot hang head down from a rope by my tail and get things plumb, but she still sticks to it that the only way to do is to cut out all the preliminaries. I judge Mr. Grant is in about the same mood.

I feel more like thanking Brown & Sharpe for putting up a most satisfactory staging for us to work on until this most recent, or future perhaps, tooth, the sinusoidal, appears. It certainly has been a most convenient staging. It has reduced the science of gear teeth to a simplicity where any boy with the necessary education to add two and divide by ten can figure the diameter of a gear. There is no doubt but that this simplicity of computation was a large factor in the quickness with which the system was absorbed. If now we are coming to the point where designers will say that this system is all right as a good average, but that they have special conditions where, say, a shorter, stronger tooth is needed, we surely have some men outside the shops of the gear specialists who can meet the demand and add something other than two to the number of teeth before dividing.

After seeing the wonderful slide rules which seem to come to life in a certain section of the country, with commendable regularity, I wonder that Mr. Grant sees anything but pleasure in a change of gear-tooth systems.

I doubt if anyone seriously expects to throw his involute cutters in the scrap. We do expect, however, that if special cases demand special designs we will make them. We also expect that if the special cases become numerous enough to classify they will be classified, and if some manufacturer, foolishly expecting a profit, turns out cutters to fit the requirements of some one of these classified specialties, nothing can be done to prevent it. If, as a remote possibility, one of these classified specialties should prove more popular than was expected, and should meet a larger number of conditions it might, of course, finally entirely supersede the old system. In this event we would all sympathize deeply with Brown & Sharpe and send them flowers, regrets, etc., as well as orders for a new form of cutters.

Springfield, Mass. ENTROPY.

Tools for Finishing Grooves in Pistons

Seeing Ethan Viall's description of an adjustable tool for finishing piston-ring grooves, on page 287, brought to mind another tool used for the same purpose in a London gas-engine shop.

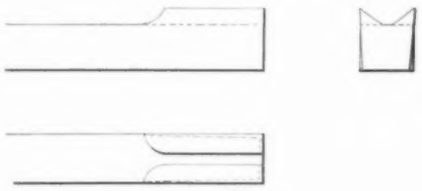


FIG. 1

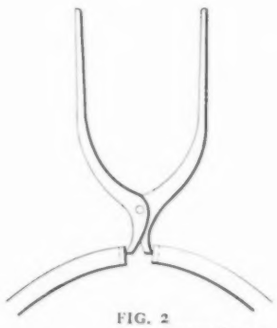


FIG. 2

American Machinist, N.Y.

THE SLOT-FINISHING TOOL AND THE PLIERS

As shown in Fig. 1, the top of the tool is milled or filed so as to form acute-angle cutting edges. This tool leaves the sides of the grooves much smoother than when finished with a flat-top tool, and would be worth trying combined with the slit and adjusting pin described by Ethan Viall. At the same shop men on assembly work are provided with the tool shown in Fig. 2. This is used for putting rings in place in the grooves, or removing them. The ends of the rings where they are cut have a slight nick filed across. The pliers are inserted in the opening in the ring, with the hooked ends engaging the nicks. Closing the other end of the pliers then springs the ring open, enabling it easily to be put in place or removed.

London, England. B. LAWRENCE.

Analyzing for Carbon Content of Steel

In No. 6 of the present volume of the AMERICAN MACHINIST, I noticed an article written by Albert F. Shore entitled "Remarkable Facts in Tempering Tool Steels." This I read with much interest, especially those statements relative to the inability of the chemist to determine the percentage of carbon in steel.

The above writer makes the statement that steel which is, by the present methods, analyzed as containing 1.25 per cent. carbon, really contains only 1 per cent. of hardening carbon; 0.25 of the carbon being derived from the carbonic oxide, chemically expressed as CO, which is occluded in the steel. This statement is wrong, as it is contrary to nearly all the facts in my experience in this line of work, and I will point out some facts which will show that these statements are not wholly in accord with our knowledge of carbon in steel.

About 20 years ago there were several crucible ingots of plain carbon steel made at the Crescent Steel Works, Pittsburg, Penn., which afterward became widely known as the International standards. Samples of these ingots, which were single-potted, were sent to many chemists, both in this and European countries, so that the methods for their full analyses could be compared. The results obtained on carbon contents compared very well, notwithstanding the fact that they were analyzed by several distinct and independent methods.

One chemist in particular who is an authority on gas analysis, converted the carbon in these samples to carbonic acid (CO_2) by direct oxidation of the drillings. The resulting carbonic acid was purified, collected, and its volume measured. From this the percentage of carbon was calculated.

All the other chemists determined the carbon indirectly by first dissolving the drillings in a solution of some of the salts

of copper, then filtering off the carbon and burning it to carbonic-acid gas by several of the well known methods. The gas was then absorbed and weighed. These two methods are entirely different yet their results were in close agreement.

Let us consider these methods. The above citation of a direct combustion of the carbon in steel, and measuring the volume of gas was looked upon with much interest. It was to my knowledge the first attempt of directly oxidizing the carbon in the steel to carbonic-acid gas. It was a new method and just what was wanted at that time. Up to that time most chemists were in doubt as to whether they were really getting all the carbon in the steel or not by the indirect or solution method. It was thought that when steel drillings, especially if hardened and crushed, were dissolved in a solution of copper salt some of the carbon would be converted into a hydrocarbon, a gas, and be lost. The close agreement in the results of the direct and indirect methods settled the question and was received with much satisfaction by chemists in this line of work.

In the direct method all the iron, carbides of iron, carbonic oxide, etc., are oxidized into oxides. Hence the occluded gases, such as carbonic oxide (CO) and carbonic-acid gas (CO_2) would count as carbon, since they, together with the carbide of iron, are all converted into carbonic-acid gas (CO_2), the ultimate form in which carbon is determined.

In the indirect method, when steel (not alloys) drillings are dissolved in a copper solution, the occluded gases, such as CO, CO_2 and H_2N are all liberated and consequently are lost, leaving a residue of quite pure carbon. The carbon is then filtered off, burned to carbonic-acid gas and weighed.

In the direct method all the CO and CO_2 would be reported as carbon, while the indirect reports only that which exists as carbides of iron, principally Fe_3C—cementite.

The direct method has recently been greatly developed and is now largely used in all steel laboratories. At the Crescent Steel Works, both methods are in daily use. Checks run against each other agree within the limits of experimented error, which we regard as a fraction of 0.01 of carbon.

If Mr. Shores' statements were true in the example he gives the direct method should give 1.25 per cent. and the indirect 1 per cent. carbon. In our laboratory, where two methods have been used in parallel many times, this is not the fact. It would be utterly impossible to get concordant results by these two methods if 0.20 per cent. of the carbon reported in steel was derived from the occluded carbonic oxide.

Occluded gases in steel is an old story. All steels contain it more or less irregularly distributed. Some have much more than others; the amount being largely dependent upon its composition and manufacture. For instance, when a piece of steel is heated to the point where alpha iron is transformed into beta iron there is a sudden evolution of gas, also when beta iron is transformed into gamma iron.

These are all well known facts. It is, therefore, in reference to the quantity of these gases that we differ. It might be said that in drilling a piece of steel all the occluded gases escape; and it is true that some is lost in this process, but not all. We have purposely used coarse drillings in the direct process, to establish limits, beyond which, other conditions remaining equal, we could not go.

If the drillings are too coarse, we get low results, due to imperfect oxidization. By prolonging the operation all the drillings can be oxidized, which will then give a result that will agree very well. I will add check results made April 12, 1909, on two different samples analyzed by these two methods:

Sample Number.	Percentage of Carbon by Solution Method.	Percentage of Carbon by Direct Method.
1	0.90	0.91
2	0.89	0.89

These certainly do not indicate that something like 25 per cent. of the carbon is lost in analyzing the steel as Mr. Shore would like to have us believe, but on the contrary, it goes to prove that almost the entire carbon contents of steel are obtained by analysis.

Pittsburg, Penn. PHILO KEMERY.

The Uncertainties of Gasolene

A recent article in the AMERICAN MACHINIST on "Nonexplosive Gasolene Tanks" again emphasizes the fact that every now and then there appears upon the market a patent gasolene can of some sort. Sometimes a powder is offered for sale which, if poured into the gasolene will render it harmless, and a series of tests are performed to show how harmless the gasolene is under these conditions. Now all of these tests have been and can be performed with an ordinary coal-oil can by one who understands the properties of gasolene.

Gasolene will vaporize at ordinary temperatures. The vapor when mixed with sufficient air will explode, otherwise it will burn with a small blue flame. There is no more danger in touching a match to the mouth of a full can of gasolene than there is in lighting a gas jet. The can and the pipe are both filled with an explosive, but as the quantity of air which can reach the vapor or gas is small, there will be no explosion. The ratio of the volumes of liquid gasolene and air for an explosive mixture is about 1-7500.

If a can is half filled with gasolene and at a temperature of 70 degrees Fahrenheit or more, the liquid will vaporize so rapidly as to fill the upper part of the can with vapor. If the can be well shaken, the liquid will vaporize more readily. When the gas is seen coming from the mouth of the can it may be ignited with as little danger as the full can. The gasolene may be poured out of the flaming can as long as there is enough liquid present to keep the can filled with vapor. This trick has been performed any number of times.

A lighted cigar can be dipped into liquid gasolene and it will be extinguished immediately. After shaking off the particles of liquid gasolene the cigar can be lighted and smoked as before.

The greatest danger from a gasolene can comes when it is empty. Ask anyone who has worked in an automobile-repair shop and who has tried to solder a leaky can. The gasolene is all poured out and left to stand over night. Then oftentimes enough vapor will remain in the can to cause an explosion when the flame of the torch or hot iron is brought near the can.

A screen like that in the Davy lamp must be kept cool in order to prevent the passage of the flame. If it becomes hot it can ignite the vapor on the other side just as the old hot tube used to do in the gas engine. It is a safety device simply because the screen cools the gases below the ignition point as they pass through it.

A fire broke out in a refinery where a high-grade gasolene was manufactured. A tank of the product was in the midst of the fire but did not explode. The tank was riveted together and so was able to withstand the increased pressure due to the gasolene vaporizing, but as no air was present there could be no explosion.

Another time a woman filled a gasolene stove and then wiped off the top with her apron. Soon afterward she started the fire. While near the stove her apron caught fire and before it was extinguished she was badly burned and the cottage was a wreck. The gasolene should have vaporized immediately and not stayed on the apron, but you can never tell what it will do. Again, the writer was trying to start a gasolene engine; after two hours' experimenting it was found that too rich a starting mixture was being used. When apparently all the gasolene had been poured from the starting pump, a mixture was forced in that ignited at the first trial and there was no further trouble.

Experiences with gasolene can be told without number and they all go to show that there is no telling what gasolene will do. It is, therefore, a dangerous liquid and should be handled with care, though the sale of patent cans is apt to make people careless in the handling of gasolene.

A well constructed can will decrease the dangers, but will not entirely eliminate them, and it is well for everyone to understand the dangers lurking in a can of gasolene.

Gasolene will float on water and the only way to put out a fire is to smother it by throwing a heavy rug or sand on the fire, thus cutting off the air supply.

Newark, N. J. S. J. BUSCHMAN.

Annealing Iron Castings

Replying to A. H. Steel's inquiry at page 486 about annealing gray-iron castings, I will offer a suggestion which, although I have never tried it directly, I see no reason why it would not do the work in a much shorter time than 30 to 48 hours.

Instead of packing the castings in charcoal or any ordinary filler, use black manganese and pack the castings in it with as little space as possible, about 1/16 or ⅛ inch between the inside of the box and the castings to be filled with the manganese. Then heat the whole until sure that every part has been brought to about 1500 or 1600 degrees Fahrenheit and let it cool off slowly in ashes or lime. I think that it will be found that the heat will not have to be applied for more than an hour. I use black manganese for softening chilled gray-iron castings in spots, by applying an ordinary gasolene torch against the spot covered with the manganese.

I for one hope that if Mr. Steel gives this method a trial he will let the editor of AMERICAN MACHINIST know the results so that others may benefit.

Ottawa, Can. W. L. MCLAREN.

Balancing Threshing Machine Cylinders

The article on "Balancing Threshing-machine Cylinders," published on page 48, was read by me with much interest, because the subject is seldom touched upon by writers, and because the operation of securing a running balance in threshing-machine cylinders was a part of my business many years ago. Often since then I have seen the usefulness of the knowledge, then acquired, and so much needed in balancing other things.

It would be impossible to give a more comprehensive idea of this operation than was done in this article, and yet a very essential feature of the art of finding the place where the counterbalance is to be applied was left out.

In our practice we did not use the guessing method for locating the counterweight, as described, but found its needed location by an infallible test. As was stated, the frame on which the cylinder rests naturally vibrates when a high speed is attained and the cylinder is not balanced. Apart from this frame, but near to the shaft at each end, we fixed stationary supports arranged for supporting the hand while making the test, which is to locate the heavy side of the cylinder. A piece of chalk or other marking device may be used, allowing it barely to touch the shaft. The cylinder is then stopped and the mark thus made located, but, strange to say, this mark is not exactly opposite the place where extra weight is to be applied, and there must be some guessing done after all. Practice, however, soon enables the operator to locate the proper place for the balancing piece, as well as its probable weight, and he inserts it a little ahead of the mark, say, eight or ten degrees showing, without analyzing causes, that the weight that disturbs the balance precedes the vibrations about to the extent indicated.

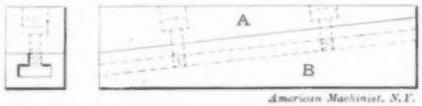
Of course a number of trials must be made before the job will pass as perfect, especially when the highest speeds are given the cylinder. When a second test is made and the mark coincides with the the previous one, this indicates that the proper place for the counterweight was found, but that it was either too heavy or too light, as may have been shown by an increase or decrease of the vibrations, as compared with those of the first trial.

Chattanooga, Tenn. A. Q.

An Adjustable Parallel

Seeing the adjustable wedge by C. Olivetti on page 191 puts me in mind of an adjustable parallel I saw in the Elgin Watch Company a few years ago.

A slides on top of *B* which has a T-slot cut in it. Two screws run through *A* and into the slot in *B* where there are two nuts that slide in the T-slot. It is set with a micrometer and the screws hold it fast. It can be made to take in as large as wanted. I saw them take in ¼ to ¾ inch.



AN ADJUSTABLE PARALLEL

Muskegon, Mich. EDWARD PORSBERG.

Filing Notes and Magazine Clippings

F. A. Halsey describes his filing system on page 399 and must, therefore, take the consequences of starting me on the index question.

Having collected and clipped for years, I have discovered one fact; most of my clippings are from the AMERICAN MACHINIST or from papers of the same standard size. A few are smaller and not one in a hundred is larger. I therefore, clip the whole page and have a box to receive it that will take it without folding. The box opens on the top and side in the same manner as a letter file and I have letter division pages and extra divisions for various subjects in which I am particularly interested.

When I find a small article, if I already have a clipping on the subject, I clip it close and paste it on to the original clipping on the part of the page not occupied by the useful article. If there is no such clipping or there is not room on it for more, I paste it on an advertisement page of the AMERICAN MACHINIST and file the page. This makes all my clippings and notes of a standard size and easily handled. I weed out once in a while and it is at this time that I do my clipping and pasting to get all my articles on to a fewer number of standard sheets. I never have two articles on different subjects on the same sheet excepting in the rare cases where two articles I wish to save are on the same page. In this case I have to keep them both together but make a note of the fact on a sheet in the place where the article should be. When enough notes of value are received it costs little to have them bound.

I index each article in the upper right-hand corner with the first three letters of the name. I formerly used an index with this but found it of little value, my articles being themselves indexed, I can locate them there just as quickly as by going to an index first. It also has the advantage of having all my clippings on any subject in one place. As an instance, suppose I have to design a piston for a gas engine. I go to my index and take out all the pages on pistons and I have all my clippings on the subject before me.

The beauty of my system lies in its simplicity. When I read an article I wish, I simply take out the page, mark three letters on it in pencil and slip it where it belongs. Of course, I will sometimes find something I cannot clip but can still make a note of it and file it where it belongs. This ought to interest the ones who have clipped for a while and then let an article go simply because they were too lazy or tired to index it at the time, only to find out six months latter that it was just the article that they need.

On page 405 T. P. has an article on "Short Cuts in Arithmetic." I agree with him that they are no shorter the way his pocket book gives them, but I would like to bring out one point in which they have their value. There are a great many machinists, and good ones too, who cannot use a formula, however simple. In a right-angle triangle for instance, tell them the two legs are three and four inches and the formula for the hypotenuse is:

$$X = \sqrt{A^2 + B^2},$$

where

X = hypotenuse
A = one leg
B = other leg

That is about all the good it would do them. Tell them to square each leg, add the results and take the square root, and they think it is a snap.

This may read like an exageration but it is the truth. I have been coaching several of the boys who are taking a cor-

respondence course and this is their main trouble. If they see a letter they are stuck but give them the figures and they can work anything.

Milwaukee, Wis. JOHN BAILEY.

Patents and Patent Experiences

The experiences of a patentee detailed on page 362 are doubtless of a very usual order. When a man proceeds to get out a patent he ought first to find out how many patents out of each thousand can survive even four years. Then he should ask himself whether his patent is one of the likely survivors, or better still, he should ask some candid friend to tell him the truth. Even when a patent is good, or rather for a really good idea, it by no means follows that the patentee is going to make a success of it. In this country it seems to require the whole period of a patent to get it taken up. By that time the inventor has died of worry and want of food, or has no means left, if alive, to fight infringers.

Plenty of good things die for lack of capital. Plenty of others die from too much inventor. There ought to be a sort of national bureau to pronounce on the merits of an invention. Then if good the inventor should be placed out of want and afforded assistance if called for. But as for 99 per cent. of them, they ought to be kept from any interfering in design or manufacture, for they can never carry a thing forward to the commercial stage.

One of the most important duties of a technical expert is to distinguish between patents that are and are not worth helping on. A friend came to me once; he was very full of a rotary engine which he was desirous of helping and out of which he was ultimately to gather many shekels. It was a really clever engine; had no toothed gears and possessed a minimum of complication. It was a genuine product of inventive genius and hard work; was well made; ran quietly and did work. But it had certain limitations which would not, perhaps, appeal to the lay mind. But it was an engine which had a certain field of usefulness if capital had been available and it was a thing that would have been interesting to play with had one had speculative capital.

I got over the difficulty by advising any friend to embark his capital if he could afford to lose it, but not to do so if the amount of capital involved was more than he could lose with a light heart. I finished my report by drawing his attention to the existing multitude of rotary engines, and stated that I had seen others of which I could speak as well as of this one; I pointed out that of all the crowd I did not know of a single rotary engine then on the market. Is it likely, I asked that you have discovered the one success? He was wise and did not venture. Yet I would have liked to have helped the inventor if I could have done so with justice to my client.

Many inventions come along which are good in themselves yet do not carry out their object any better than do other devices. It is thus not possible to place such inventions though it would have been so, had it not been for prior devices as good or nearly so. Yet many men do put more money into patents who have no knowledge of the subject. I well recollect a man who had put about $20,000 into a patent for a mechanical stoker. It fell to me to conduct him to see the machines at work. At the same place was a machine stoker of another make. My surprise was great, when he saw the other machine and asked, "So there are other mechanical stokers in existence?" I explained there were of the order of a dozen in common use. His surprise was indeed great. He had invested his dollars in the belief that the stoker was the only one, and he became very silent and his lost dollars, for they were lost, weighed heavier on his mind than in his pocket. Now that man had practically been swindled, for he believed himself to be investing in a machine that had no competitor but the hand shovel. Had he met me sooner and paid me 1 per cent. of what he proposed to invest he would have left the thing alone, for it was no manner of good anyway.

Most of the inventions of any value are got out day by day by men who are at work on the particular line of business connected with the article patented. Occasionally some man comes forward who is a stranger to an industry and he does something in a way quite different from anyone else. His very ignorance has been his help. Had he known how things were done it is possible he would have attempted to improve along already beaten paths. But the revolutionary invention is rare.

Thousands have worked at the steam engine. Had boilers been strong enough it is probable that the piston engine would never have superseded the turbine. High boiler pressure and Watts' air pump and separate condenser have, however, brought about the users' citation of the Hero steam turbine, which is regarded by the layman as a revolutionary invention. It is, of course, nothing of the sort. Mechanical affairs have a way of developing along certain lines. The fittest service—no one can exactly tell us how it is that in respect of the reciprocating steam engine, the only successful engines have been those which have developed along certain fixed lines. These lines are those of the locomotive, as regards horizontal engines, and the marine engines, as regards vertical engines. We have seen all manner of fancy engines grow up. They have attained, it may be, a certain measure of popularity, but they have come to nothing. Single-acting engines have dropped out; engines with fancy arrangements of cylinders are no more. The high-speed engine has made a success only so far as it has become like an ordinary marine engine.

Now, this experimental history of mechanics, if it could be written out fully by some man who has made a special study of mechanisms, would show his inventors what to avoid. The best thing they can avoid is a patent unless they have ample proof of its value and ample means to pay the piper; that is, to fight infringers. There are always infringers, some of whom infringe because they are persuaded that the particular patent is not fair matter for a patent. Others infringe because they wish to profit out of another man's invention, being born thieves, who will steal from any inventor if he cannot fight. In this country a patent for four years does not cost much, but the next ten years pile up a big sum in annual fees; these fees are ruin to most inventors. There are plenty of men who literally spend their lives in poverty to pay patent fees. There has lately been started an agitation to abolish all patents in this country, as they have been abolished in Holland, on the ground that practically there is nothing really new to invent. One writer points out that the patent law practically forbids all but one man from bringing out an improvement in any given line oftener than once in 14 years. He holds that if inventions were free they would still be made; that good things would still secure financial aid and that there would be simply a sort of open, secrecy in the matter.

I once knew of a patented machine, which was absolutely good and new for its purpose, yet it was declared by a patent lawyer to be of doubtful validity. The owners of the patent worked it openly; all trade rivals knew of it. It netted its owners at least $100,000 per annum for several years, while the patentee himself received $5000 a year in royalty. But a skilful diplomacy kept off all rivals. The patentee only drew his royalty on the condition that it lapsed if there was any attempt to infringe. And no one did infringe.

Had there been no patent the same thing would have happened. In short it takes years to get manufacturers out of the ordinary groove, and in this country the constant tendency is for old established businesses to die out and for new ones to take their place. The new undertakings are run by the progressive men who could not secure due recognition of their services in the old establishments. There are, of course, many brilliant exceptions to this.

London, England. W. H. BOOTH.

There are 30,000,000 pounds of old rubber shoes each year that go through some sort of press to be reformed and revitalized into commercial values.

The Washington Meeting of the A. S. M. E.

Valuable Papers, Pertinent Discussion and Royal Entertainment Marked the Spring Meeting of the Mechanical Engineers, Held May 4 to 7, 1909

EDITORIAL CORRESPONDENCE

The program of the spring meeting of the A. S. M. E. was varied from the usual arrangement, the evening reception and dance taking place on the opening evening of Tuesday. The address of welcome was given by Hon. Henry B. F. MacFarland, President of the Board of District Commissioners, and the response by President Smith of the society.

Wednesday's Sessions

Following the reports of the tellers of the election and of the membership committee, the chief business of importance transacted at the business session was the preliminary reading of proposed amendments to the constitution, on which action will be taken at the next meeting.

The first of these came from the membership committee and related to the better definition of the qualifications for associate membership, which are now ambiguous. An addition was also proposed to the qualifications for junior membership, making candidates for that grade over thirty years of age ineligible. Another amendment was read by Professor Hutton and proposed the addition to the list of standing committees of another, to be called the Public Relations Committee, the idea behind this being to have regularly organized society machinery for the intelligent handling of public questions of an engineering character.

The first paper taken up was by Ellis C. Soper, its title being "A Unique Belt Conveyer." It described an unusually long belt conveyer which, running down hill, consumed less power when loaded than when empty. The principal discussion of it was by Mr. Bennett, who criticized the conveyer as being in no sense unique. He said that there are many others just as long, many that run down hill and some which when loaded require brakes to hold them from running away. Further discussion by Mr. Emerson, Mr. Miller and Mr. Dinkel criticized the statements made from an economic standpoint.

The second paper related to automatic feeders for handling material in bulk, by C. K. Baldwin, who described feeders to be used in connection with belt conveyers. In the discussion Mr. Bennett pointed out the importance of the automatic feeder, in that by securing uniform loading it largely reduced the width of the conveyer belt.

The two remaining papers of the session, on "A New Transmission Dynamometer," by Prof. Wm. K. Kenerson and on "Polishing Metals for Examination with the Microscope," by Albert Kingsbury, will be published in these columns at an early date. The discussion of Professor Kenerson's paper was extremely complimentary, one speaker pointing out that by reason of its small size it may be used in making road tests of automobiles—such tests now being confined to laboratory instruments and to artificially imposed conditions. He hoped to make such tests in the near future.

Wednesday afternoon the society and its guests were entertained by an exhibition cavalry and artillery drill at Fort Myer—the drill eliciting round after round of applause. One sweet young thing who did not quite catch on was heard to say that this exhibition was the best thing she had ever seen the Mechanical Engineers do.

Wednesday evening the society listened to a lecture by Chief Engineer Davis of the Reclamation Service on the progress of the various irrigation projects now under construction in the West. The lecture was illustrated by a large number of superb lantern slides which were of unusual interest—those illustrating the before and after conditions bringing out repeated rounds of applause.

This work is a conspicuous exception to the usual slow rate of progress of Government work. The law authorizing the work was passed less than seven years ago and the progress shown by the lantern slides is nothing less than extraordinary.

Thursday's Sessions

If there was ever any doubt about the wisdom of the society in organizing the Gas Power Section it was removed by the lively interest and great success that attended its session of Thursday, the attendance being, moreover, excellent.

The session was opened by the reading by C. L. Straub of a report on the progress in the use of the producer gas engine as applied to marine propulsion in Europe. While some progress has been made and the field for this system of power is universally felt to be very large, universal difficulties with the producer as applied to the burning of bituminous coal are found. Following this report Mr. Straub presented a paper on "Marine Producer Gas Power." The paper describes and gives plans for, a lake freight carrier equipped with producer gas engines of 1000 horsepower, which, however, has not yet been built. In view of this perhaps premature publication the author explained that a similar plant of 300 horsepower capacity has been in operation for over a year with results that justify the publication of the paper.

The paper was discussed in connection with the next one on the program on "The Operation of a Small Producer Gas Power Plant," by C. W. Obert.

The most valuable information brought out in the discussion was given by Mr. Holmes of the Geological Survey, who explained that at the beginning of the work of the Survey in connection with gas producers, the two great difficulties found were connected with the obtaining of gas of uniform quality and with the disposal of ashes and clinker. Entirely satisfactory progress has been made in disposing of the first difficulty and good progress with the second.

The third paper of the session was on "A Method of Improving the Efficiency of Gas Engines," by Thomas E. Butterfield, which was read by title. Some written discussion had been presented, but, being chiefly mathematical, it was taken as read and passed on for publication in the **Proceedings.**

The concluding paper on "Offsetting Cylinders in Single Acting Engines," by Prof. T. M. Phetteplace, has already been published in abstract in these columns. The paper brought out an animated discussion, in which the chief participants were Mr. Herschel and Mr. Norris. The former had investigated the problem for large horizontal engines—the paper relating to the small vertical engines of automobiles. His conclusions are that the smallest advantage of the offset cylinder attends its use in high-speed four-cycle vertical engines and its greatest advantage in slow-speed horizontal two-cycle engines. Mr. Norris referred to the long experience of the company with which he is associated which, after making offset cylinders for many years, is now abandoning the practice and making all its new designs with the cylinders and shafts in line.

The afternoon was given up to a White House reception by the President, which was attended by a large number.

The evening of Thursday was occupied by an address on "The Engineer in the Navy," by the former chief engineer of the navy department, Rear Admiral George W. Melville; an address on "Admiral Melville's Service to the Engineering Profession and to the Nation," accompanied by the presentation to the National Gallery of a portrait of Admiral Melville, by Walter M. Macfarland, and

the acceptance of the portrait by Dr. C. B. Walcott.

Admiral Melville began by reviewing the movement for the consolidation of the line and engineer corps of the navy, which he believes is working out well, and followed with a sharp arraignment of the recent reorganization of the navy yards. Mr. Macfarland's address was a touching tribute to the Admiral, who in the speaker's days in the navy, had been his superior officer.

Friday's Session

The session on Friday morning was opened with a paper on "Small Steam Turbines," by George A. Orrok, the paper being chiefly descriptive of the different classes of turbine now available. The discussion was animated, the general impression being that while the small turbine has a field that it can well occupy, it cannot become a general competitor of the high-speed steam engine. It was generally admitted that the economy of the small turbine when run noncondensing is not as good as that of the reciprocating engine, its low cost of maintenance and upkeep being the chief factors leading to its use. Mr. Forbes mentioned a turbine which was installed in New York in 1852 and ran for fifteen years with entire success. Mr. Rice believed that the impulse turbine would eventually displace the reaction type for all sizes, but against this Professor Carpenter gave the opinion of Mr. Parsons that for large sizes the reaction turbine would eventually occupy the entire field.

The second paper of the session was on "Oil Well Tests," by E. M. Ivens, the paper describing the rearranging of an equipment of air-lift pumps in the Southern oilfields, and giving the results of tests before and after the reconstruction. The paper received no discussion.

Following this came a long but not very pointed continuation of the discussion on safety valves, which was originally taken up at the New York February meeting. At the conclusion of the discussion it was announced by the president that a research committee on safety valves had been appointed.

As the hour was getting late the remaining papers on the program—"Specific Volume of Saturated Steam," by Prof. C. H. Peabody, "Some Properties of Steam," by Prof. R. C. H. Heck, and "A New Departure in Flexible Staybolts," by H. V. Willie, were read by title.

After the passing of the usual resolution of thanks and of a resolution offered by Professor Hutton calling for action by the council relative to improving the conditions in the patent office, the meeting adjourned.

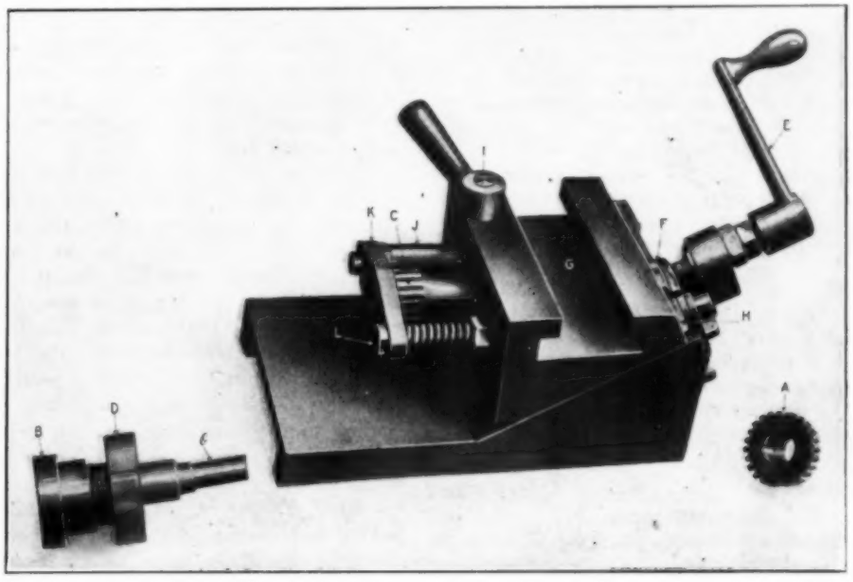
The afternoon was occupied by a trip to the home and tomb of Washington at Mt. Vernon and by an exhibition of a dirigible balloon at Fort Myer.

An Efficient Keyseating Fixture

By H. L. Vawter*

In modern machine-tool building any special tool or fixture which tends to increase the output or improve the quality of work is eagerly welcomed by the manufacturer. As a prominent superintendent in the trade once remarked to the writer, "quality and quantity" spell success in modern manufacture. I am inclosing a photograph of a small special fixture which illustrates both subjects to a greater or less degree. It is cheap to make, and easy to operate.

In our shop we have a great many blind keyways, 1/8x3/32x3/4 inch long, to make as shown in the work marked *A*. The former method was to drill a small hole 3/4 inch deep, as near the edge of the bored hole as possible, and break out the keyway with a small gouge the same width as the key. This was a very tedious job and not satisfactory.



AN EFFICIENT KEYSEATING FIXTURE

Finding an old lathe cross slide among our relics, its method of operation gave me an idea, which I finally worked out into the tool shown. Referring to the illustration, the body of the fixture is an old rise-and-fall tool block, adjustable up and down an angular slide. *A* is the work showing the keyway to be cut; *B* the cutting tool with the high-speed steel cutter *b*, brazed in position, and *C* is the work in position to be cut.

In operation the body of the fixture is bolted to the shaper table, or held in the vise, whichever is the most convenient. The regular shaper toolpost is removed, and the tool *B* is placed in the clapper block with the cutter *b* down, and held securely by screwing up the nut *D*. After carefully centering the cutter with the work, the shaper ram is adjusted to the proper stroke to make the keyway the required length, and the machine is ready to start.

By turning the handle *E* we pull the block *G* up the angular slide of the base, causing the cutting tool to feed into the work and at the same time shortening the travel of the tool enough to prevent its jamming and breaking at the end of the stroke. The depth of the keyway is regulated by adjusting the lock nuts *F* on the elevating screw. When the keyway is finished, the slide is returned to the original position which may also be adjusted by the stud and lock nut *H*. The work is then released by a half turn of the handle *I*, which is an eccentric stud working in the plunger *J*, a spring back of which forces it out, loosening the latch *K*, which may then be swung up and out of the way on the stud *L*, the spring on which merely serves to hold the latch against the end of the stud and prevent it from falling clear over. The work is then removed from the short stud (not shown) on which it is located, another piece placed in position and the operation repeated.

As may be seen, every part is adjustable, and by slight modifications this device may be used for a number of different jobs, such as small gears, pinions and similar small parts. After the fixture is once set up and adjusted properly, any bright boy can operate it and get the best results in both accuracy and speed.

In lots of one hundred the keyseat in the cast-iron ratchet, as shown in the illustration, can be finished in about one minute, with one sharpening of the tool for the whole lot.

*Department foreman, John Steptoe Shaper Company.

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Automobile Accidents

As a source of accidents and fatalities the automobile now stands in the limelight of publicity, and while we are far from excusing the recklessness of some automobile drivers, we believe, nevertheless, that as a source of newspaper copy automobile accidents have been worked at the expense of others equally and more deserving of notice.

The entire subject of accidents is receiving a large amount of deserved attention, but of all the numerous sources of accidents, a minor one, the automobile, receives more attention than, perhaps, all others combined. It is in this city especially that much space has been devoted by the daily papers to automobile accidents, and while such accidents have deserved all the attention they have received, the fact, nevertheless, remains that accidents and fatalities far exceeding in number those due to the automobile pass unnoticed except when they are accompanied by spectacular features.

The police records of this city show that between January 1 and April 10 there were 434 vehicular accidents within the city limits, of which 162 were due to street cars, 167 to horse-drawn vehicles and 90 to automobiles. Looking at the matter in a larger way, the report of the Board of Health for this city for 1906, the last which we have at hand, shows a total of 3781 deaths from violent causes not including murders and suicides, this being an average of over 10 per day, most of which passed unnoticed, which they would not have done if caused by automobiles.

The explanation of the prominence given by the daily press to automobile accidents is undoubtedly that the machine is a new factor in our civilization and that the accidents caused by it are public in their very nature, added to which is the proper indignation at the recklessness of a few automobile drivers and their attempts to use their machines as means of escape when this recklessness leads to serious consequences. That such drivers need a sharp taste of the law we would be the last to deny, and in bringing this about the present agitation is the natural and perhaps necessary means. At the same time it remains true that the automobile is not the leader as an engine of destruction that many have come to regard it, the commonplace street car and the horse-drawn wagon which pass almost unnoticed, leading it in large numbers as the above figures testify.

The matter has been largely complicated by the improvement in our streets due to the introduction of asphalt pavements, which has brought about a large increase in the number of pedestrians who cross the streets where they should not. In a legal sense the pedestrian has the right of way on the crossing but not elsewhere on the highway, and while this is the last reason that can be given for any lack of care by an automobile driver, the fact remains that the prevailing practice has largely increased his difficulties as well as the pedestrian's danger.

When the ordinary speeds of automobiles and of horse-drawn vehicles are compared it is at first sight surprising that the latter should be a more prolific source of accidents than the former. The result is doubtless due to the superior control of the automobile driver over his vehicle. The quickness and certainty with which an automobile may be brought to a stop can only be fully appreciated by those who have operated one of the machines. But for this and for the further fact that it is scarcely possible for it to run away, the two classes of vehicles would doubtless change places as sources of accidents.

Are We Neglecting Drilling?

Drilling is such a common operation, without doubt the most common of all in the shops, that we are apt to think very little about it. Yet, if the experience of some of those who have studied the subject very carefully counts for anything, it is perhaps the least understood of all our shop operations.

Taking the question of drill speeds and feeds, we find a wide range of opinions, the greatest difference being with speeds, the feed per revolution being fairly well understood in most cases, and not being materially affected by the change in speed. The chip that can be taken by the lip of the drill does not depend on the speed except as the size of the chip might affect the proper cooling of the lip in the case of carbon drills.

The experiments that have been made indicate that, as a rule, high-speed drills can stand about double the speed of carbon drills in most cases, which, with the same feed per revolution, make a saving of one-half in the drilling time. This does not necessarily mean that it will always pay to use them as the actual drilling time may be very little as compared to total time which must include handling. On the other hand, there are probably many cases where the higher cost may be justified even without a saving in drilling time, owing to the longer time between grinding and the more constant operation of the machine.

When it comes to small holes there is no doubt that the average shop loses time by not being able to run the drills at an economical speed. Drilling machines are usually bought to give a fairly wide range of capacity and it is very evident that a machine which will drive a 1-inch drill will hardly be economical on 1/16-inch drills which should run sixteen times as fast. To run a 1-inch machine at such a speed means undue wear and power consumption, and while we do not usu-

ally pay much attention to power used by machine tools a little figuring will show that it may easily become a serious matter. Taking a horsepower at $75 per year, which seems to be considered a fair average by many shop managers, we can readily see that every wasted horsepower will go quite a way toward buying a small drilling machine that is specially suited for the higher speeds that are more economical.

Those who are carefully studying the drilling question predict much higher speeds on small drills, limited almost by the ability of the machine to run at a high speed, and correspondingly higher speeds of larger drills, based on a cutting speed of 125 to 150 feet per minute at the outer edge of the lip for brass and from this down to 80 feet per minute for steel.

While these are higher speeds than are generally used, we are informed on good authority that they can be easily maintained under good conditions and with proper lubrication. It is certainly a field that is well worth looking into and one in which considerable saving can probably be effected at a comparatively small outlay.

Thomas Aldridge Weston

Thomas Aldridge Weston, inventor and mechanical engineer, died in New York City on May 3, in the seventy-eighth year of his age. Although born in Birmingham, England, Mr. Weston was a thorough American in more than a legal sense. He came to this country when quite young, and for a time was a clerk in the old hardware house of Pratt & Company, Buffalo, N. Y. He had an inventive mind and a natural aptitude for mechanics, and from this parentage sprang his first and most widely known invention, that of the differential pulley block, which in later years became recognized as an addition to the so-called "mechanical powers."

This differential block was an adaptation of the old Chinese windlass, and is a reduction of a mechanical problem to its simplest terms. The invention was patented in Great Britain and the United States; the licensees in the former case being Tangye Brothers, Limited, Birmingham, England, and for this country the Yale & Towne Manufacturing Company, Stamford, Conn. It was instantly recognized as a most valuable mechanical appliance and rapidly passed into general use.

Mr. Weston's next notable invention was that of the multiple disk brake, which in various forms, has since been widely used in connection with machines of many kinds, especially in cranes and hoists.

His third and last important invention was that embodied in the well-known "Triplex" chain block, also made by the Yale & Towne Manufacturing Company. The original principle of the differential block involved a large waste of power, whereas, in his later development a greatly increased efficiency was obtained.

Besides these inventions Mr. Weston devised many practical improvements in other lines, the latter part of his life being occupied in the study of mechanical problems, many of which he worked out to a successful conclusion.

He was a man of culture, refinement and exceptional intelligence, whose contributions to the mechanic arts will give him a permanent place among the inventors of the past half century.

The National Supply and Machinery Dealers' Association

An interesting convention has been arranged for the fourth annual meeting of this association, held at the Fort Pitt hotel, Pittsburg, Penn., May 12, 13 and 14, jointly with the American Supply and Machinery Manufacturers' Association.

Several papers dealing with trade conditions and policies are down for discussion and the entertainment committees of both associations have arranged a program of recreative diversion that is sure to prove successful.

New Publications

AUTOMATIC SCREW MACHINES AND THEIR TOOLS. By C. L. Goodrich and F. A. Stanley. Hill Publishing Company, New York. Cloth, 255 pages, 6x9; 284 illustrations, 27 tables. Price, $2 net.

This book is intended as a treatise for the use of toolmakers, screw-machine operators, tool designers and others connected with the construction and manipulation of automatic screw machines and turret lathes. It is arranged in two parts: Section 1 illustrating the various types of automatic screw machines and their tool equipments, and Section 2 dealing in detail with the construction and use of screw-machine tools. In addition to detailed descriptions of the different types of "automatics" and "semi-automatics," Section 1 explains fully the methods of laying out cams for the Pratt & Whitney and Brown & Sharpe machines, the cam adjustments on the Cleveland automatics, etc. The chapters on camming contain, besides diagrams, numerous tables for facilitating the operation of laying out the cams. A chapter on speeds and feeds is included in the book and should be of service when laying out cams and setting up machines, as the tables in this chapter cover speed and feed rates for all kinds of screw-machine tools operating on the ordinary classes of material. Including single-spindle, double- and multiple-spindle, magazine and semi-automatic machines, nineteen machines of the following makes are illustrated in eighteen chapters of Section 1; Acme, Alfred Herbert, Brown & Sharpe, Cleveland, Gridley, Potter & Johnston, Pratt & Whitney, Prentice, Spencer, Universal. The illustrations show in addition to the machines themselves, turret and cross-slide tools, special attachments, countershaft diagrams, etc.

The chapters on camming referred to and a number of the chapters on cutting tools were prepared originally for publication in the columns of this journal. They are arranged in this treatise in more convenient form for reference and much additional matter has been included. The nine chapters in Section 2 should be of special value to the toolmaker, as these treat extensively of methods of making and using spring collets and feed chucks, forming tools, box tools, drills and counterbores, taps and dies, nurling tools and other appliances. Referring, for example, to the chapter on forming tools twenty pages and thirty-six illustrations are devoted to such tools and their holders, detailed information being given for making both circular and dovetail tools, this covering all the steps intervening between the model or drawing of the work and the completion of the tool itself. Convenient formulas are given for finding the diameters of circular tools at different points and diagrams show the dimensions of standard forms of cutters. Examples are presented of practical methods of applying the tools to long and short work, to plain and complicated outlines. The questions of cutting action, clearances, lubrication, etc., are discussed and these important matters as pertaining also to box tools, drills, reamers, counterbores, dies and taps, cutting-off and other tools are treated fully in the chapters dealing specifically with these tools. Sizes of radial and tangent cutters for box tools, dimensions of taps and dies and other tools are given in different tables and the entire section will be found of interest and service to the man who designs, makes, or uses screw-machine tools.

SHAFTING, PULLEYS, BELTING AND ROPE TRANSMISSION. By Hubert E. Collins. Hill Publishing Company, New York. Cloth; 157 pages, 4½x7 inches; illustrated. Price, $1.50.

This is another of the *Power* handbooks, made up largely of material which has appeared in the columns of *Power*, and has thus had the advantage of previous presentation, discussion and revision. It contains practical directions for the putting up, lining and leveling, and the care and maintenance of shafting, belting and rope transmissions, splicing of ropes and belts, etc. It treats the subject from the practical rather than the academic standpoint and should furnish the man who uses it hints which will be worth many times its cost.

New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make it Possible To Do Better Work at a Reduced Cost

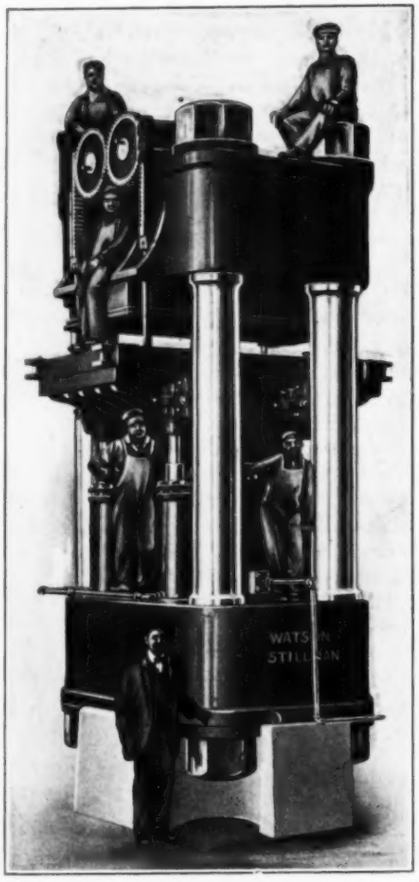
THE LATEST INFORMATION

4000-Ton Hydraulic Press

The press shown is interesting not only on account of its large size, but it was built under specifications which stipulated that the moving platen should not spring more than 0.01 inch under the maximum load of 4000 tons. It was especially designed by the Watson-Stillman Company, of New York, to compress a plastic material to almost uniform thickness within a mold of which the upper and moving platen form the top and bottom faces, respectively. The sides of this mold consist of a practically solid steel band 7 inches high and 5 inches thick which rests on the moving platen while the material is under pressure. That uniform dimensions and great density of finished product are secured is shown from the fact that the top of the mold clears the sides by about 1/64 inch, and that 8,000,000 pounds pressure can be equally distributed over the mold (about 25 square feet in area and about 9 feet across the diagonal).

The operating pressure is 5800 pounds per square inch on the main ram, which is 42 inches in diameter. With the exception of the ram which is of chilled iron, all parts under stress are of steel. The three platens are steel castings, and the columns are of machinery steel. The cylinder is cast from nickel steel. This construction keeps the total weight of the machine down to 115 tons and also reduces its size.

The stroke of the ram is 18 inches, but the actual work of compression is accomplished through less than one-tenth of that distance. A hydraulic accumulator is used to speed the ram up to load and the operating pressure is then taken direct from the hydraulic pumps. After the material has been compressed the sides are raised by turning the operating pressure into the four 6-inch stripping cylinders, whose piston rods pass up through the moving platen and rest near the corners of the flask, the racks and pinions preventing any irregularity in lifting. The stripping-cylinder rams have a travel of 23¼ inches, so that they will bring the flask down into position on the moving platen when the main ram is at the extreme bottom of its stroke. The main ram lowers by gravity when the operating pressure is released and thus sends the water in the cylinder back into the pump reservoir.



HYDRAULIC PRESS

Continuous Belt Grinding Machine

An interesting development of the belt-grinding machine made by John C. Blevney, 216 High street, Newark, N. J., is shown in Figs. 1 and 2. In this the belt is horizontal instead of vertical, the work being held on another belt and passing under it. The long grinding belt *A* runs outside of and is driven by the corrugated or cushioned leather belt *B*, while the weighted pad or foot *C* keeps a constant pressure on the work as it passes under the grinding belt.

The work or carrying belt is fitted with holders of any kind suited to the work to be ground. These pieces to be ground are placed in the pan *D* at the back from which the operator places them in or on the holding fixtures, fitted to the carrying belt. It is shown at work on some hardened-steel punchings which pass under the belt, and are not only polished, but ground very closely to size about as fast as an operator can handle them.

These carrying belts can handle any-

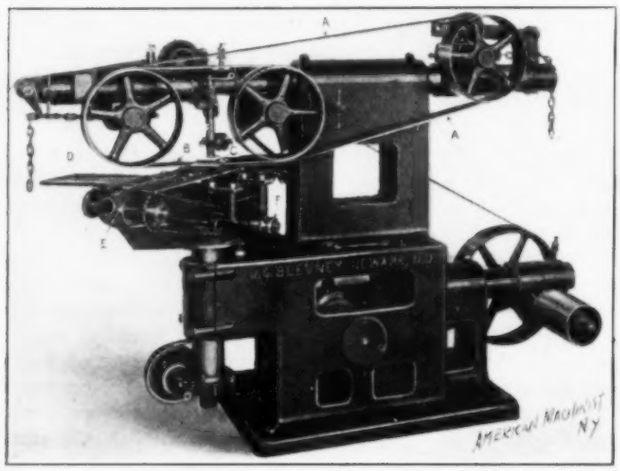


FIG. 1. CONTINUOUS BELT GRINDING MACHINE

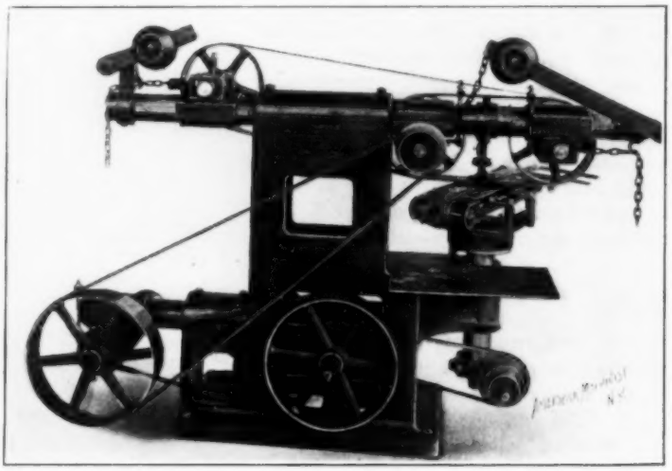


FIG. 2. REAR VIEW WITH ATTACHMENT FOR FINISHING PUNCHINGS, ETC.

thing up to 4 inches in width, are interchangeable so that belts can be kept for special work and can be readily changed from one to the other. The work belt can be stopped instantly by pulling the clutch hand *F*, the angle of the belt easily changed at will and any other fixture desired substituted.

Fig. 2 shows the other side of the machine, and shows all the driving belts, the combination of spring and weight tighteners for the different belts, and other details. As the pieces come to the end of the belt they drop off on the table or into a box. On small work the output reaches 4000 pieces per hour.

The grinding belt travels about 7000 feet per minute and a very ingenious joint is made which gives a strong belt and at the same time one which presents no extra thickness to the work. This is made as in Fig. 3, the ends interlocking and being pressed flat and to the same thickness as the belt itself. This splice can be readily understood by noting the reference letters, the ends *A* coming from the left and *B* from the right. The area in contact is shown by the lettered spaces. The joint is protected by a separate patent.

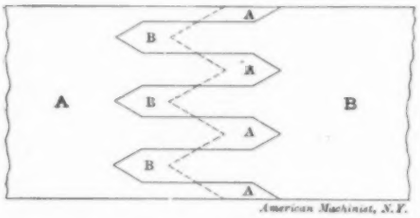


FIG. 3. THE SPLICING OF THE BELT

A Large Drawing Instrument

Large drawing boards for planning out tools and machines full size are not unusual in large shops, but they do not often have a special drawing instrument, as shown in the accompanying illustration. This should be particularly useful in automobile building, as shown. The whole framework, which forms a T-square hung from the top, is very substantial and is easily moved from place to place. The drawing instrument itself is of the Noyes design and gives any desired angles. This is made by the Emmert Manufacturing Company, Waynesboro, Penn.

LARGE NOYES DRAWING INSTRUMENT

A Neat Tool Chest

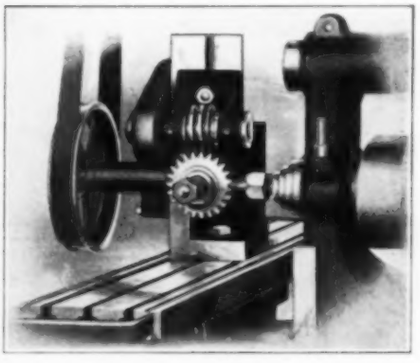
The extremely neat and compact tool chest, or set of tool drawers, shown in the accompanying illustration is one of several styles made by H. Gerstner & Sons, Dayton, O. The chest shown is covered with an imitation leather, has

A NEAT TOOL CHEST

locked corners and is very substantial in every way. The lid or cover slides in under the lower drawer, so as to be out of the way when the case is open for use. The lid forms a felt-lined tray, which is very convenient in many ways. The case has a spring lock and the leather handles make it easy to carry.

Tooth Chamfering Attachment for Milling Machine

This machine has been redesigned since its appearance a year ago and is now made as shown instead of with the gear on a vertical spindle. The whole attachment is mounted on the milling-machine table and set at the correct angle to get the desired finish on the teeth. The worm meshes into the gear itself, indexing it



TOOTH CHAMFERING MACHINE

automatically and allowing it to be fed forward by a cam contained in the mechanism. This makes each gear self indexing regardless of the size or pitch, all that is needed being a worm to fit the different pitch gears.

This can be used to chamfer the ends of teeth of gears located midway on a

shaft, which is a great convenience in some gear boxes and the present position of the gear allows all chips to drop away from the mechanism instead of into it. It works very rapidly, chamfering about 12 teeth per minute and its normal range is for gears from 2 to 9½ inches pitch diameter and from 4 to 10 diametral pitch, which will cover all ordinary requirements for sliding gears. It is made by the Long-Arm System Company, Cleveland, Ohio.

Developments of the Lo-Swing Lathe

The centering of work to a uniform depth is more important when it comes to duplication of pieces, but to make it easier to secure satisfactory results without extreme care in this respect, the Fitchburg

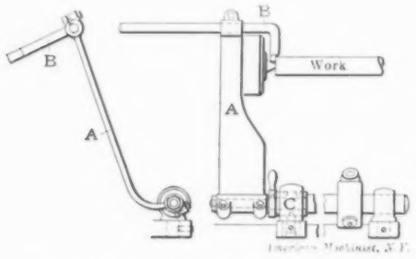


FIG. 1. ADJUSTABLE STOP FOR LO-SWING LATHE

Machine Company, Fitchburg, Mass., has put its carriage stops on an adjustable bar which is set by the end of the piece next the face plate. An arm *A* carrying the bent stop *B* is put on the end of this rod and is swung up until the end of *B* is near the end of the work; then the whole rod is moved by the screw in *C* until the stop arm touches the work. This locates all the stops and shoulders from the head end of the work. The stops are as rigid as before and are all located together with reference to the end of the work.

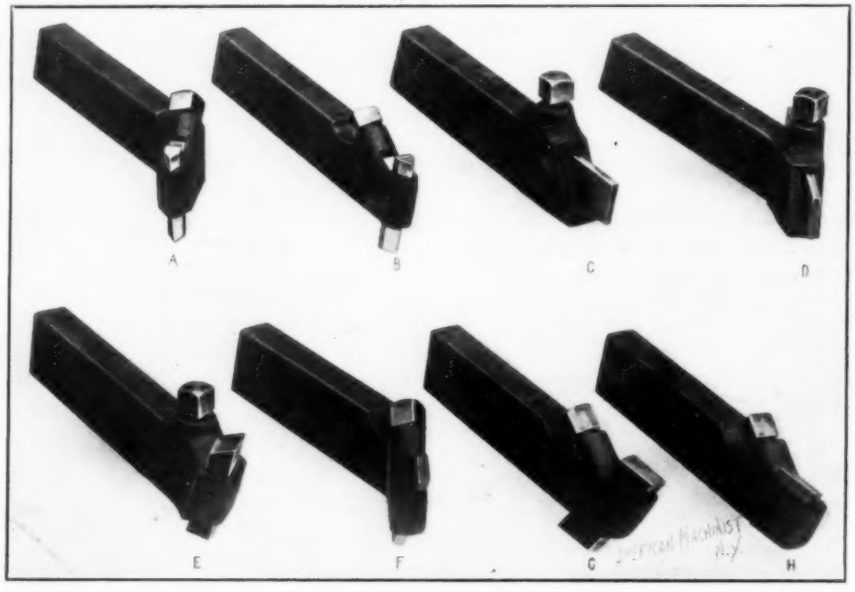
Some of the special tools used on these lathes and the way in which shoulder work is handled, are shown in Figs. 2 and 3. The first case shows a cam shaft made up from a forging and containing 8 cams. The first operation is to turn *A* and place the steady rest against it. Then the cams are all faced with the special tool that cuts down four sides at once. Next is the forming of the two collars *B B* and lastly the turning of *C* and *D* by the tools in the second carriage.

The next operation is to reverse the shaft in the lathe, turn the main diameter *E* with the first carriage and the end *F G* with the second carriage, turning the shoulder. Fig. 3 shows a motor-car axle turned from the solid to the dimensions shown. The first operation is to turn the long, main diameters *C D* with the leading tools of the first carriage. The small end *A* is roughed down with the first tool of the second carriage, then the taper *B* turned with the special taper tool following the former at the back, and finishing the end *A* to size.

Then the piece is reversed in the lathe, the short length at *E* turned, and *F* finished to size.

Lathe Tool Holders

The halftone shows a line of tool holders which has recently been brought out and is known by the trade name of the



LATHE TOOL HOLDERS

"Red E" tool holders. They are designed to take stock sizes of either carbon or high-speed steels so that no shaping nor blacksmith work is necessary except in the case of the threading tool, on the back of which a ratchet is formed. The hold-

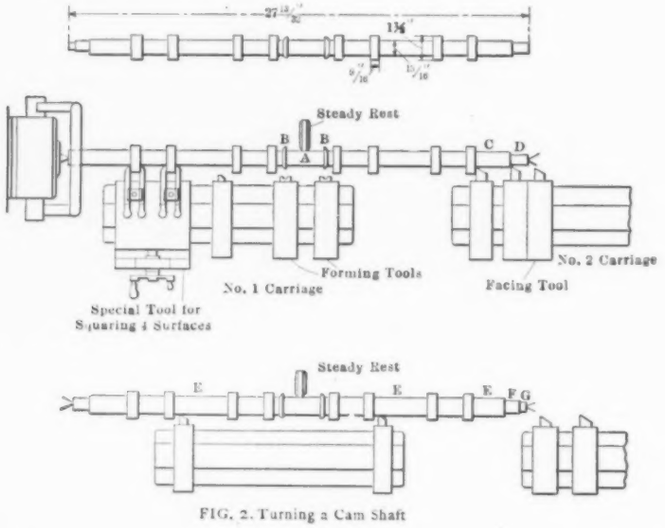


FIG. 2. Turning a Cam Shaft

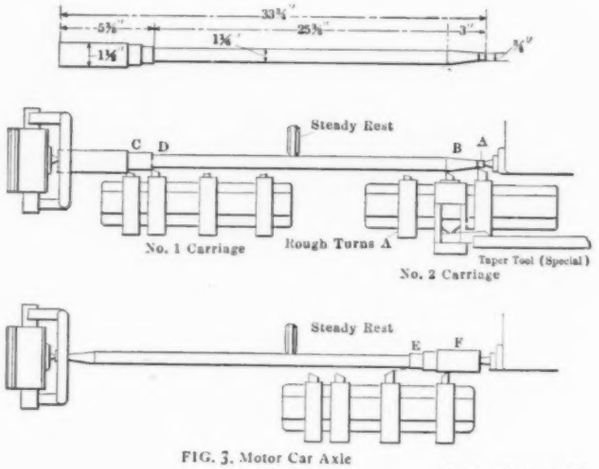


FIG. 3. Motor Car Axle

American Machinist, N.Y.

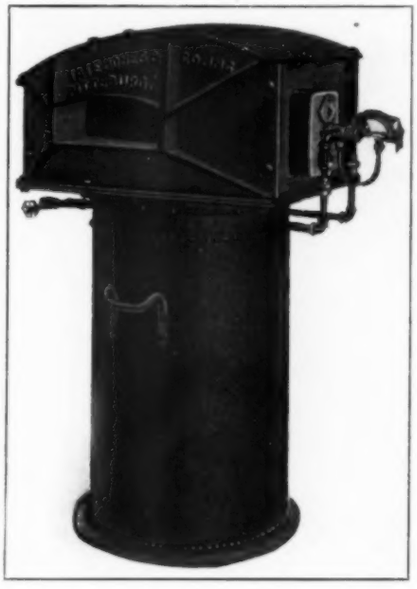
METHODS OF DOING WORK ON LO-SWING LATHE

ers themselves are so shaped as to allow end- and side-cutting clearances; because of this the cutters require grinding on one face only, saving considerable loss in time and material. *A* and *B* show, respectively, the offset and straight threading tools. In these the cutter is serrated at the back and is held in position by a wedge, having serrations on the face of it, which is clamped securely against it by means of the set screw. *C* and *D* show, respectively, the straight and offset parting tools. In these the cutter is held by the set screw on the top and a small, blind set screw at the side which takes up any side play. *E* shows the diamond-point tool which uses common square stock. A right-hand tool is shown in the illustration, but by simply blocking back the set screw and turning the square cutter round it becomes a left-hand tool. *F* shows an offset right-hand side tool. *G* a straight right-hand side tool and *H* a straight left-hand side tool. In these three tools the cutters are held by the set screw at the back and when dull require grinding on the top face only, the side and front clearances being provided for as previously stated in the holder itself. These tools are made in various sizes and are manufactured by the Ready Tool Company, New Haven, Conn.

The Kirkwood Forge

Due to the marked advancement in structural building during recent years as regards the magnitude of the actual methods employed, the builders of machinery, used in this class of work, have been working over time in the endeavor to perfect their tools, machinery, appliances and methods, to be specially adaptable for the new conditions.

This was very prominently brought out recently by the Kirkwood Forge, as shown



THE KIRKWOOD FORGE

in the halftone, which employs a radically different principle both in construction and fuel.

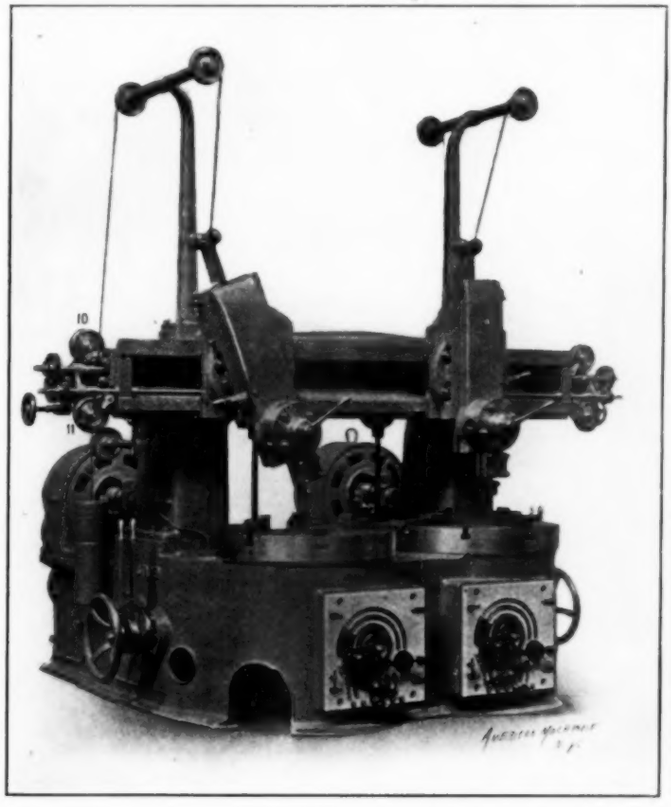
Fully aware of the inconvenience and danger of transferring and storing coke or coal at the great elevation required, as well as of the winds encountered, The Tate, Jones & Co., Pittsburg, Penn., placed this forge on the market.

It is composed of a light but strong iron frame, with a specially designed brick hearth. The fuel, which is crude oil, is retained in a tank located in the base of the forge. This when filled holds enough fuel for one or two days continuous run. The compressed air is secured from the regular supply which is the equipment of all such structures.

The "Kirkwood" burner, with which these furnaces are equipped, is of such construction as to assure an absolutely perfect mixture of air and oil for perfect combustion. The ratio adjustment is made at the factory and cannot be interfered with by the operator, thus a uniform flame is always secured. The hearth is protected from wind and weather by a hood which also confines the heat. These furnaces are made in several sizes and shapes.

A Double Vertical Boring Mill

This is a rather striking design for a boring mill, with its two tables, independent motors and tool equipment, being virtually two single-head machines. The tool slides both have four hole turrets and a swiveling saddle. The counterweight is behind and to one side of the housings, acting through the shaft carrying the pulleys and maintaining a straight pull by the



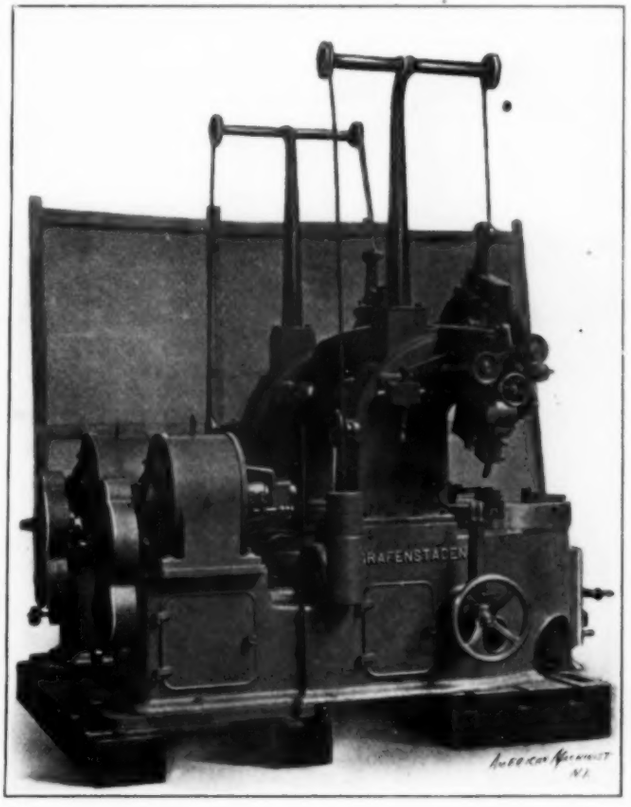


FIG. 1 FRONT AND SIDE VIEWS OF DOUBLE VERTICAL BORING MILL. FIG. 2

guide pulleys shown. The use of steel tapes, as indicated in Fig. 2, is a little out of the ordinary, although it has been advocated by Prof. John E. Sweet for many years.

Some of the constructive details of the swiveling heads are shown in Fig. 3, as well as the feed mechanism at the right.

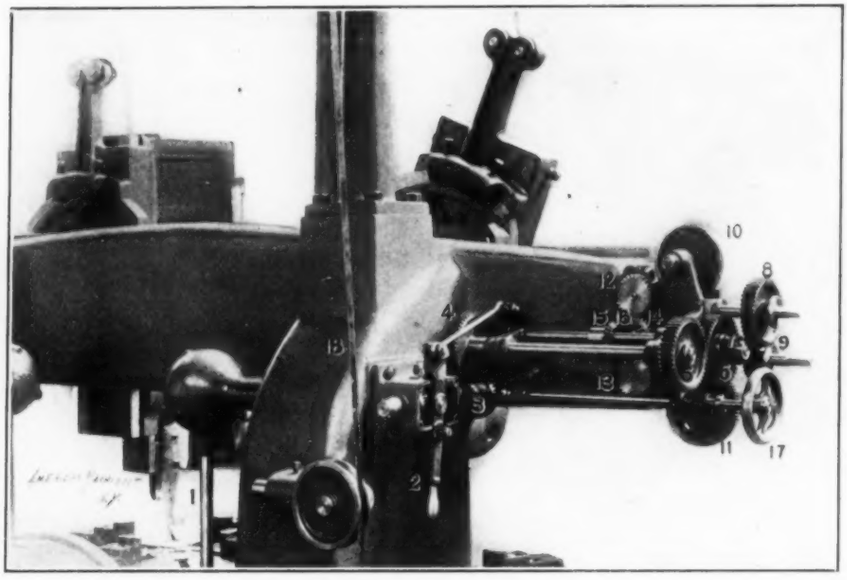


FIG. 3. FEED GEARING IN CROSS RAIL

The power comes up through the vertical shaft 1, transmitting it through bevel gears to the worm and gear 3 and 4, under control of the lever 2. From here it goes through the gear train shown to shafts 8 and 9 which carry worms that mesh into the wheels 10 and 11. These carry stops

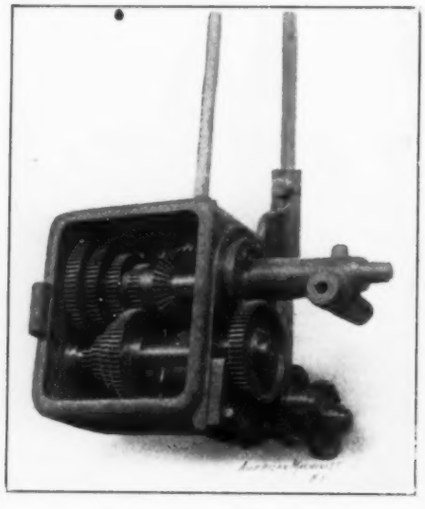


FIG. 4. THE FEED BOX

which can be set at any part of the circular groove and act on the short levers shown in Fig. 1, which are connected to the spur gears 12 and 13 in Fig. 3 and act, through the bevel gears, on the main clutch lever 2. Hand feed is obtained by wheel 17 being pushed in to engage the worm 3 by means of the bevel gears shown. The feeds shown control the cross movement of the saddle and the vertical movement of the slide.

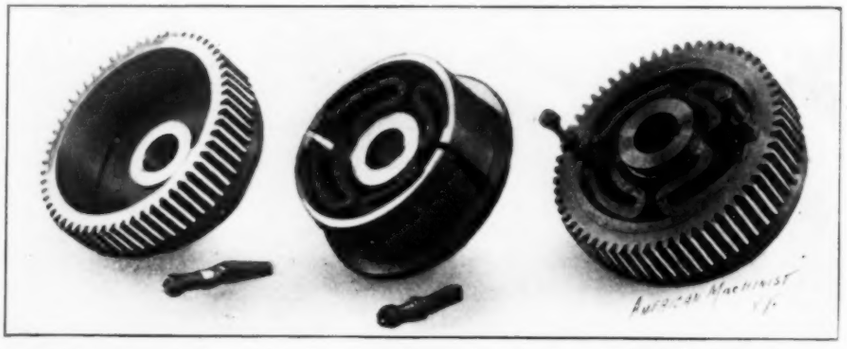
The Main Gearing Train

Fig. 9 shows the main gearing train very clearly, and by noting the position of the motor in Fig. 2, we readily see that 19 is the pinion on the motor shaft, 20 the intermediate and 21 the main driving gear of the train. Gears 22 to 25, together with clutch 33 give two changes of speed while gears 26 to 29 and clutch 34 give the rest in combination with the first set. From here power is transmitted through bevels to the spur pinion and to table. These clutches are controlled by the levers at the side of the bed.

The clutches and gears, together with the tightening wedges are shown in Fig. 5. A view of the double bed, with its bearing surfaces and oiling rollers is seen in Fig. 6, while the table construction is made clear by Figs. 7 and 8.

The feed box is inside the bed and is of the double cone-of-gear-type, as shown in Fig. 4. The sliding key is controlled by the rack shown, which is moved in and out by a pinion mounted below and moved by the large hand wheel outside the two clutch levers. Power for the feed box is taken from the gear 30 in Fig. 9, which meshes into the train of spur gears outside the gear box.

The general appearance of the machine is pleasing, and the details have been worked out very carefully. The machine is built by the Société Alsacienne de Constructions Mécaniques, Grafenstaden, Alsace.



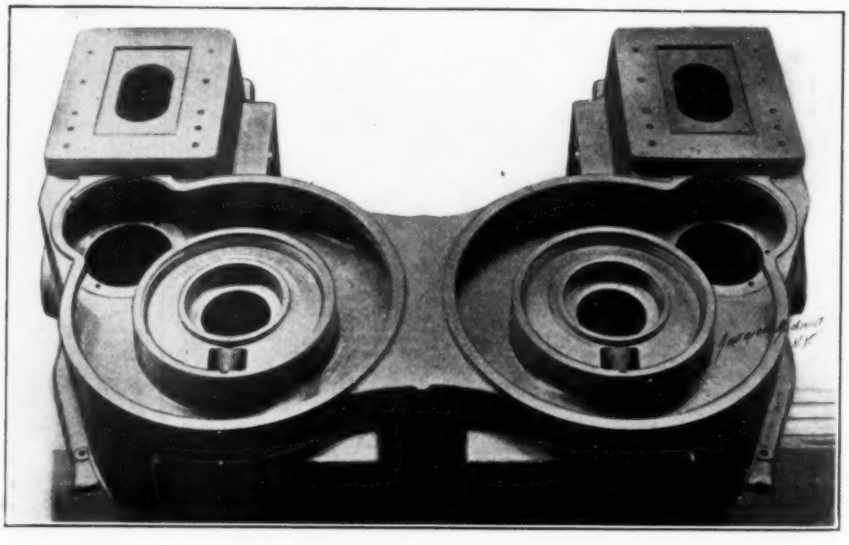


FIG. 5. DRIVING GEARS AND CLUTCHES
FIG. 6. THE BED WITH TABLE BEARINGS

The Significance of Draft in Steam-Boiler Practice

On page 473 we presented an article entitled "A Revolution in Steam Boiler Practice Foreshadowed." This dealt with the experimental work of Professor Nicolson and indicated the possibilities of enormous improvements in apparatus for burning coal and generating steam. Several months ago on pages 284 and 285, Vol. 31, Part 2, we reviewed Bulletin No. 325 of the United States Geological Survey, in which similar suggestions were made as to what might be looked for in the near future in furnace and boiler performance.

Another bulletin of the United States Geological Survey, No. 367, has just been issued and touches upon the same field. It is entitled "The Significance of Draft in Steam Boiler Practice." It deals with an extensive and important series of experiments, which is described in detail, and from it many conclusions are drawn. An introductory paragraph is: "The experiments so far made seem to indicate that it is possible to double or treble the capacity of a plant without making any radical changes in the furnaces and boilers. These increases require about double and treble the quantities of air to be put through the fuel beds and boilers. It also seems probable that re-baffling the boilers will often permit the capacity to be doubled or trebled, while still getting more steam than formerly per pound of coal for uses outside the boiler room. These experiments were undertaken with the object of clarifying ideas concerning the passage of air through fuel beds and boilers."

Nature of the Experiments

The larger number of experiments recorded were made with a special apparatus, consisting of an air measuring vessel connected with a tube, in which there were two layers or beds of lead shot. One of these remained constant and represented a boiler; the other was varied in regard to the size of shot and the depth and represented the fuel bed. Air was passed through these two beds and careful observations made of its temperature and pressures above each bed. Deductions made from the results of these experiments are applied to the conditions surrounding the draft in the various parts of a boiler furnace and connections.

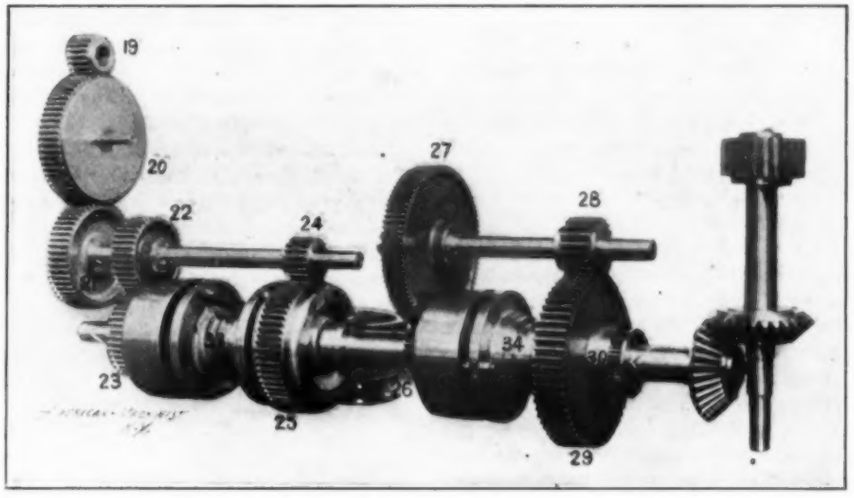


FIG. 9. THE MAIN DRIVING-GEAR TRAIN

Law of Drop of Gas Pressure

A law for the drop of gas pressure from one part of a boiler setting to another is stated as follows: "(*a*) If the resistance to the flow of gases remains constant, the pressure drop through any portion of the path of the gases will have a constant ratio to the total drop from the ashpit to the uptake. Thus, for example, if the pressure drop to the fuel bed is 0.5 inch of water, when the total drop is 1 inch, it will be 1 inch if the total drop is increased to 2 inches., and 2 inches if the total drop is increased to 4 inches of water.

"(*b*) If the total pressure drop from the ashpit to uptake remains constant, the pressure drop through any portion of the gas path will vary in the same direction as does resistance to the flow of gases, although the magnitude of the variations may not be in simple proportion. Sup-

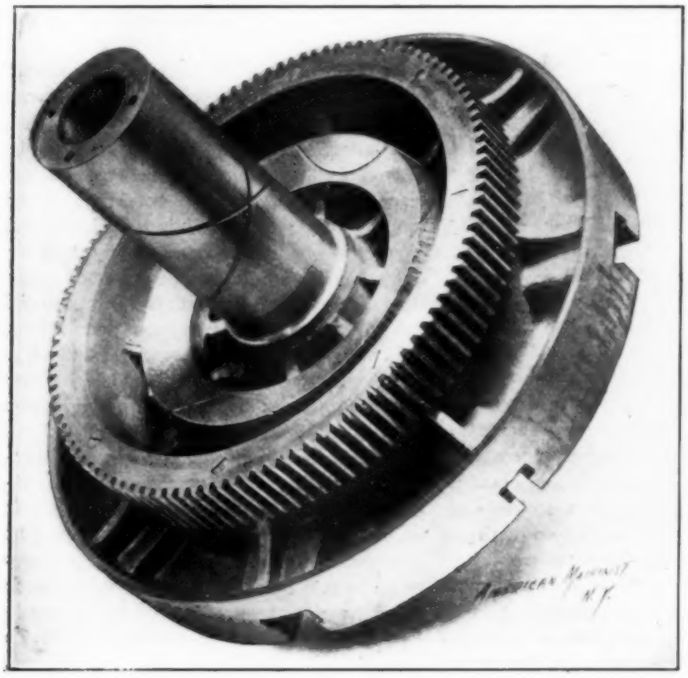


FIG. 7

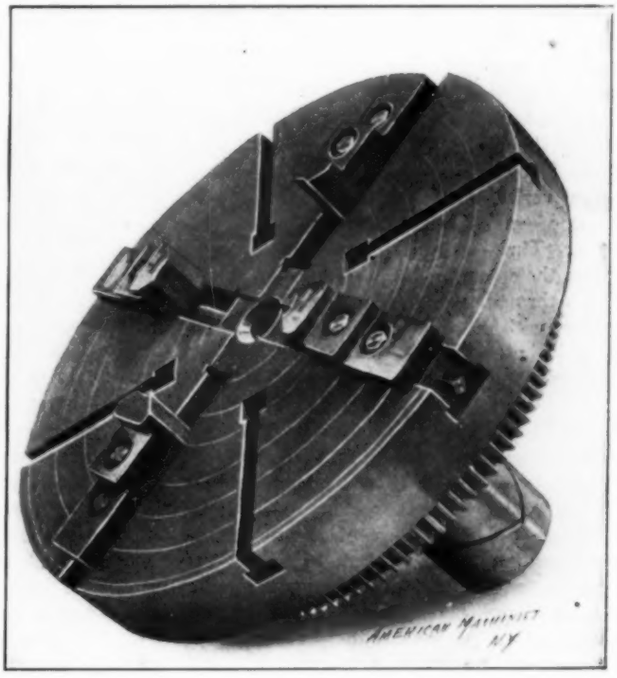


FIG. 8

TWO VIEWS OF THE TABLE

pose the total pressure drop is 1 inch of water and the drop to the fuel bed is 0.5 inch; now if the total drop be kept the same, but the resistance through the fuel bed be increased by doubling its thickness, the pressure drop through the fuel bed will increase to about 0.65 inch of water; or if, for the same total drop, the resistance of the fuel bed be increased by quadrupling the thickness, the drop through the bed will increase to about 0.8 inch of water.

"(*c*) When the resistance through any portion of a gas path remains constant, the weight of gas passing through this portion varies with some power of the pressure drop through this portion. Thus, since the resistance of that portion of the gas path from over the fuel bed to the uptake is ordinarily very nearly constant, the weight of gases passing through the furnace and boiler varies as some power of the pressure drop between these points. Approximately only, the weight of gases passing through the boiler is directly proportional to the square root of the pressure drop through the boiler, or to any portion of a gas path having constant resistance."

It is not our purpose to review the experiments that are recorded, but this section of the bulletin will richly repay reading on the part of anyone who is interested in steam boiler practice and its possibilities. There are numerous tables, and many graphical charts setting forth the experimental readings plotted under various conditions in order that lessons therefrom may be more readily drawn.

The substance of bulletin may be summarized as follows:

SUMMARY

"If the resistance to the flow of gas remains unchanged, the pressure drop through any portion of the gas passage bears a constant ratio to the total pressure drop.

"If the total pressure drop from ashpit to uptake remains constant, the pressure drop through any portion of the gas passage varies with the resistance to the flow of gas through that particular portion. Thus, with a constant total drop from the ashpit to the uptake the pressure drop through the grate and the fuel bed varies with the resistance of the grate and fuel bed, the variation being in the same direction but not of porportional magnitude.

"If the resistance of any portion of the gas passage remains constant, the weight of gas passing through that portion varies as some power of the pressure drop through it. The index of the power is approximately 2, so that in order to double the weight of gas passing through, the pressure drop must be quadrupled, and in order to treble it the pressure drop must be made 9 times as great.

"The above three statements are general for all conditions and for all combinations of 'forced' and 'induced' draft. There is really no difference between 'forced' and 'induced' draft, provided the setting is tight.

"'With gases there is no pulling, only pushing.' Gases travel from places of higher pressure to those of lower, the motion of the gas occurring because of its expansion.

"Experiments shedding light on the flow of gases through boilers were made in a laboratory by passing air through two beds of lead shot. The results of the experiments are expressed in the following brief paragraphs:

"The rate of flow of air through a bed of shot of constant thickness is approximately proportional to the square root of the pressure drop through the bed.

"As the thickness of the beds of shot increases the weight of air passing through per minute decreases very rapidly at first, then more and more slowly.

"To put air at the same rate through twice as thick a bed of shot requires twice the pressure difference between the two sides of the bed and twice the work must be expended.

"If the hight (number of rows of tubes) of a cross-flow type of water-tube boiler be doubled, or if the length of the tubes of a parallel-flow type of water-tube boiler be doubled, or if the thickness of a fuel bed be doubled, it is likely that the work required of a fan will be about doubled if the same weight of gas is to be passed through per minute.

"Increasing the length of a multi-tubular boiler and leaving the internal diameter of the tubes the same seems in most cases to increase slightly the total amount of heat absorbed when the boiler is working under the same pressure difference between the two ends of the tubes, although the weight of air passing through is less.

"A large pressure drop through the fuel bed does not necessarily mean that the rate of combustion is high; it is likely to mean the opposite. High-pressure drop through the fuel bed always means high resistance in it to the flow of gas.

"The pressure drop through the fuel bed, or the draft over the fire, is significant only when considered in connection with the total pressure drop.

"The capacity of a boiler increases with the pressures difference between the pressures in the uptake and over the fire.

"With constant total pressure drop, the capacity of a boiler decreases as the pressure drop through the fuel bed increases.

"If two or three times the usual amount of gases be forced through a stoker and boiler so as to produce nearly two or three times as much steam, the total work expended on the fans will be increased perhaps 8 and 27 times, respectively, (2^3 and 3^3). This greater proportionate expenditure of steam will probably be figured in other operating costs, besides which there would be the great advantage of working the investment two or three times as hard.

"There is, however, a limit beyond which it would not pay to increase the total pressure drop in order to raise the capacity of a boiler. Assume that the work applied to the fan would continue to increase, as in the above three cases, starting the same at 2 per cent., for the higher capacities the steam consumption of the fan would be: For 100 horsepower a 2 per cent. steam consumption for the fan; for 200 horsepower 8 per cent.; for 300, 18 per cent.; for 400, 32 per cent.; for 500, 50 per cent.; for 600, 72 per cent.; for 700, 98 per cent. and for 800, 128 per cent. This shows that it will be impossible to multiply the capacity by more than 7. Beyond this point the fan would take more steam than the boiler would make. At 5 times the original capacity the fan would take about half the steam. Doubling, trebling and perhaps with a larger grate area even quadrupling the rate of working a boiler seems to be sound commercial practice."

Spontaneous Movement in Hardened Steel

BY J. E. STOREY

Hardening is such an absorbing subject and has so many phases that it will provide research and experimental work for both scientists and practical engineers for some time to come. One of the most peculiar and interesting phases is the spontaneous movement which continues to take place in steel articles for a considerable time after they have been hardened, and this will prove an interesting study to any who care to make it the basis of an investigation.

Its importance will readily be recognized but more particularly by those who have to do with the making of gages, taps, standards of length, etc. The trouble caused by an alteration in size taking place days or weeks, and not infrequently months after an article has been hardened is not inconsiderable; in fact it might be quoted as one of the chief sources of error in gage making, particularly in those of the homemade order, where precautions are rarely taken to overcome the difficulty.

The initial movement that takes place as the immediate effect of hardening is not referred to, but that slow, sneaking movement which not infrequently breaks a cutter for you the day after it has been hardened. How often has a cutter been left exposed all night on a bench to be found next morning cracked, and sometimes even in two pieces; and how much more often has a gage been found to be incorrect to size when one could have sworn that it was dead accurate when it was finished.

The initial movement produced by hard-

ening was dealt with in an article which appeared in the AMERICAN MACHINIST, Vol. 31, Part 1, Page 277, and it was during the course of the same experiments that an incursion was made into the phase here dealt with.

The experiments here described were undertaken in order to investigate the direction and the amount of the movement in an article after it has been hardened, and how far it could be prevented by treatment. For the purpose three pieces of crucible steel were cut from the same bar and turned to about 6 inches long and half an inch in diameter. They were uniformly annealed before finish-turning. The ends were roughly lapped to facilitate the measurement of the length; and, after being carefully measured, two of the pieces, Numbers 2 and 3, were hardened. Both were then subjected to the same hardening treatment, and at the same time. These two were then carefully measured and the amount of alteration in dimension noted, after which No. 2 only was subjected to a simple aging process and again measured. The basis of the measurements throughout the experiment was a standard of known accuracy and stability, and the comparisons were made on a Newall measuring machine.

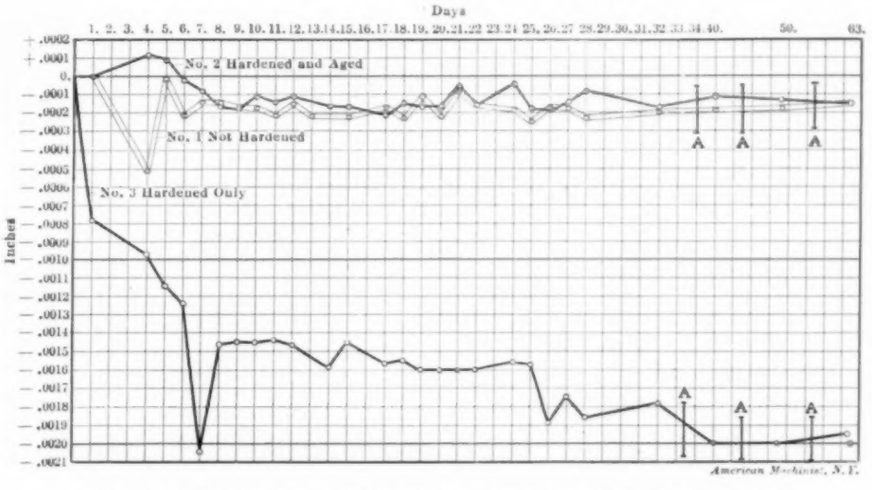


CHART I SHOWING THE ALTERATIONS IN SIZE THAT TAKES PLACE IN STEEL

At this stage began the observation of the movement. It should be noted that there were then three pieces; No. 1 was in the raw or unhardened state; No. 2 had been hardened and aged; and No. 3 had been hardened only. All that was necessary to do, therefore, was to observe the difference in the lengths of the three pieces periodically, over a course of time. All three were measured for length daily, during a course of about twenty-five days, and after that at four intervals varying from four to thirteen days. These measurements are given in Table 1, and they are plotted out in Chart 1.

The first figures in each column show the length of each piece at the commencement of the observations, or what might be called the original size. Below these the figures show the relation of the pieces to their original sizes on each day tested, while the final figures show the ultimate size the pieces reached sixty-three days after hardening. To make this quite clear; No. 3 was 5.98600 inches in length at the commencement of the observations and on the fifth day, for example, had contracted 0.00114 inch (its length being then 5.98486 inches) and the ultimate size it reached was 5.98460 inches showing a total contraction of 0.00194 inch.

An examination of the table and chart will show that in practically all cases the alterations in size were of a minus character, i.e., the articles decreased in length. No. 1, the untreated one, moved but little and after the first day or two may be said to have remained stationary. The same may be said of No. 2 which was hardened and aged and which remained as constant as No. 1. No. 3 shows very different results; this contracted no less than 0.00194 inch in sixty-three days and it did not appear to lose its inclination to contract until about the twenty-sixth day after hardening, after which it remained fairly constant.

The treatment of aging No. 2 was evidently successful because, as will be seen from the table and diagram, the alteration in this was no more than in No. 1 which had not been hardened. The chart illustrates the relative movement of the three pieces; the double line curve represents the unhardened piece No. 1. The thin line represents the hardened and aged piece No. 2, and the heavy line the piece No. 3 which was hardened only. The horizontal figures represent the days which elapsed after hardening, and each circle on the diagram shows when and where a measurement has been made. The vertical figures denote the amount of the movement in inches, each square representing 0.0001 inch. The periods that elapsed at the points marked *A* are not truly indicated in the diagram and the curves should be broken here; it has been shown so to save unnecessary length.

The aging process to which No. 2 was subjected was almost too simple to warrant so imposing a description but its simplicity does not detract from its effectiveness. The process applied to No. 2 was merely to boil it in fish oil, at a temperature of about 375 degrees Fahrenheit, for a period of about an hour after hardening. Experience had shown that this simple process exercised a very beneficial effect in preventing spontaneous movement in hardened articles, but until this experiment was made its value was not so much appreciated as it was afterward. The chart and table conclusively prove its value. The ordinary tempering of hardened work has the effect of aging and the practice of tempering was probably instituted, in the remote past, as much to prevent cracks as to remove brittleness. The usual tempering process, however, is not so beneficial as the aging or tempering process described above, which maintains an absolutely even temperature throughout the piece for a definite period.

Days After Treatment.	No. 1. Not Hardened.	No. 2. Hardened and Aged.	No. 3. Hardened Only.
	Size in Inches Before Treating.		
	5.98411	5.97848	5.98600
	Alteration in Inches.		
1	0.00000	0.00000	0.00077
4	0.00051	+0.00011	0.00097
5	0.00001	+0.00008	0.00114
6	0.00023	0.00002	0.00123
7	0.00014	0.00008	0.00203
8	0.00014	0.00016	0.00145
9	0.00017	0.00018	0.00143
10	0.00017	0.00011	0.00143
11	0.00022	0.00014	0.00142
12	0.00015	0.00012	0.00145
14	0.00022	0.00016	0.00158
15	0.00022	0.00017	0.00144
17	0.00017	0.00021	0.00156
18	0.00023	0.00013	0.00154
19	0.00011	0.00016	0.00160
20	0.00022	0.00016	0.00160
21	0.00007	0.00008	0.00160
22	0.00015	0.00014	0.00160
24	0.00019	0.00004	0.00155
25	0.00025	0.00019	0.00157
26	0.00017	0.00018	0.00188
27	0.00018	0.00014	0.00175
28	0.00023	0.00008	0.00185
32	0.00020	0.00017	0.00178
40	0.00019	0.00012	0.00200
50	0.00017	0.00013	0.00200
63	0.00015	0.00015	0.00194
	Final Size in Inches.		
63	5.98396	5.97833	5.98406

TABLE 1. ALTERATIONS IN STEEL CAUSED BY TIME.

For standards of length the method of aging generally employed, where extreme accuracy is required, is to place the standard or gage in cold oil and slowly raise the temperature of the bath to about 360 or 375 degrees Fahrenheit, maintain it there for some hours and then gradually lower it to normal again; the whole process occupying many hours. Hardened articles are liable to lose their hardness during this treatment, if kept for too long a time at a high temperature, notwith-

standing the fact that the same temperature would not draw the temper in an hour.

One feature about this experiment worthy of note is the fact that piece No. 1 decreased in length although it had not been hardened. Part of this loss might be due to wear on the measuring points, but it would be more reasonable to assume that it actually did contract, as although all pieces were annealed, the turning would cause a molecular disturbance, and this would only be thrown off by aging despite the previous annealing.

Every effort was made to prevent extraneous influences affecting the reliability of these tests and the experiment may be safely considered to have clearly established the beneficial effect of this simple process of aging upon hardened steel, and although the process is neither original nor new, this demonstration may serve to emphasize its value to those who already use it, or something similar; while to those who do not use it and have to do with the making of taps, gages, etc., it will be of no mean service.

Personals*

A. F. Wisner, for the past three years in charge of the tool-drafting department of the Pierce-Arrow Motor Car Company, severed his connection with that company on April 30.

L. E. Burton, formerly with J. T. Mooney & Co., and more recently with the W. J. McPherson Company, is now in charge of the American Blower Company's office in Seattle, Wash.

Ernst E. Gamon, who has been for some time factory manager of the Neptune Meter Company, Long Island City, has recently established himself in the same line of business in Newark, N. J.

Edmund Lang, who for five years held an executive position with the Wheeler Condenser and Engineering Company, has been placed in charge of the repair shop of the Crocker-Wheeler Company, Ampere, N. J.

A. A. Buehring, connected with the New York office of the Dodge Manufacturing Company, in the capacity of engineer and salesman, sailed for Europe on May 5 to look after some interests of the company on the Continent. He expects to be away for about four months.

Carl S. Dow, lately publicity manager of the B. F. Sturtevant Company, and formerly in charge of instruction and textbook departments, American School of Correspondence, has associated himself with Walter B. Snow, Boston, Mass., and will act on the staff in the capacity of publicity engineer in various technical lines.

B. Elshoff, for 12 years assistant superintendent of the Allis-Chalmers-Bullock Company, of Cincinnati, and for the past two years superintendent of the electrical department of the Allis-Chalmers Company, of Milwaukee, has recently severed his connection with the last named company, and for the present will remain in Milwaukee.

*Items for this column are solicited.

Alexander Miller

Alexander Miller, head of the firm of Alexander Miller & Brothers, of Jersey City, N. J., died May 6, at his home in this city of kidney disease.

Mr. Miller was born in Aberdeen 65 years ago and came to this country at an early age. He began his engineering career at the old Delamater Iron Works of this city, of which his father was superintendent. Later he formed a connection with the Deeley Iron Works and specialized in suger-evaporating machinery and more recently he applied the experience thus gained to the evaporation of brine in the manufacture of salt and with conspicuous success, the firm having produced some of the largest vacuum salt plants in the country. Three of the fire boats of this city were also the product of his works.

Mr. Miller was a leading factor in the organization of the Delamater Veterans Association, composed of his old associates at the Delamater works, and until the present year he was its president. He was also a member of Scotia Lodge, F. and A. M., the Engineers Club, the New York Athletic Club and the St. Andrew's Society. He was married ten years ago to Miss Mary Ella Rigney, of Brooklyn, who survives him. He had a large circle of friends among whom he was very popular, and a leader, and who will long remember their genial, generous, whole souled "Aleck."

Forthcoming Meetings

National Supply and Machinery Dealers Association and American Supply and Machinery Manufacturers Association, joint convention, Pittsburg, Penn., May 12-13-14, headquarters Fort Pitt hotel. A. T. Anderson, secretary, Wade building, Cleveland, Ohio.

The Foundry and Manufacturers' Supply Association, convention, Cincinnati, Ohio, week of May 17.

National Association of Manufacturers, fourteenth annual meeting, Waldorf Astoria hotel, New York City, May 17; George S. Boudinot, secretary, 170 Broadway, New York City.

American Foundrymen's Association convention, Cincinnati, Ohio, May 18-20, headquarters Hotel Sinton. Richard Moldenke, secretary, Watchung, N. J.

National Machine Tool Builders' Association, spring meeting, May 25,26, Milwaukee, Wis., headquarters, Plankington house. P. E. Montanus, secretary, Springfield, Ohio.

American Hardware Manufacturers Association, joint convention with Northern Hardware Jobbers Association, Pittsburg, Penn., June 9-11, headquarters, Hotel Schenley. F. D. Mitchell, secretary, 309 Broadway, New York City.

Railway Master Mechanics Association, annual convention, June 16-18, Atlantic City, N. J. Jos. W. Taylor, secretary, Old Colony building, Chicago, Ill.

Master Car Builders Association, annual convention, June 21-23, Atlantic City, N. J. Jos W. Taylor, secretary, Old Colony building, Chicago, Ill.

American Society of Testing Materials, annual meeting, June 29, Atlantc City, N. J. Edgar Marburg, secretary, University of Pennsylvania, Philadelphia, Penn.

Business Items

The Massey Vise Company has removed to its new plant, 208-210 Michigan street, Chicago.

On May 1 the general offices of the Independent Pneumatic Tool Company were moved from the First National Bank building to the new Thor building at 1307 Michigan avenue, Chicago.

The special high-speed steel known as "Toledo" steel, manufactured by J. Hy. Andrew & Co., of Sheffield, England, will be handled for Detroit and vicinity by Chas. A. Strelinger & Co., who will carry a complete stock of all sizes.

Announcement is made by the Garwood Electric Company, of Garwood, N. J., and 149 Broadway, N. Y., that it has acquired the exclusive right to manufacture and sell the dynamos, motors and other special apparatus formerly manufactured by the C. & C. Electric Co., and that it has taken over all the designs, patterns, drawings and tools, the engineering staff and workmen of the C. & C. Co., as well as the factory at Garwood, N. J. The Garwood Electric Company is capitalized at $250,000.

Business Opportunities

Bauer Machine Works, Kansas City, Mo., will enlarge plant.

The Olds Gas Power Company, Lansing, Mich., will enlarge plant.

The Adamson Machine Company, Akron, Ohio, will erect a new plant.

The Advance Bag Company, Middletown, Ohio, will erect a $75,000 addition.

H. E. and O. S. Lundgren, Fort Cook, Neb., will erect a new machine shop.

The Haverhill (Mass.) Box Board Company will erect an addition to plant.

The Giddings & Lewis Co., Fond du Lac, Wis., is planning to extend foundry.

The Douglas (Ga.) Foundry and Machine Company is erecting a new shop.

The Field Force Pump Company, Elmira, N. Y., will erect an addition to plant.

Bozay y Rivano, Santiago, Chile, are in the market for lathes, drills and planers.

The Buena Vista (Va.) Foundry Company has reorganized and will enlarge plant.

The Goldsboro (N. C.) Traction Company will erect repair shop at East Goldsboro.

The Improved Seamless Wire Company, Providence, R. I., will erect a new plant.

The Chicago, Milwaukee & Gary Railway Company will erect shops at Rockford, Ill.

Pelton & Crane, Detroit, Mich., manufacturers of electrical specialties, will erect a new plant.

John E. Thropp's Sons Company, Trenton, N. J., is building an addition to machine shop.

The Valley City Machine Works, Grand Rapids, Mich., is planning to erect an addition to plant.

The Lufkin Rule Company, Detroit, Mich., will erect an addition to plant to cost $10,000.

The Northwestern Metal Manufacturing Company, Minneapolis, Minn., will erect a new factory.

The Thomas Steel Company, Niles, Ohio, contemplates the erection of five additional sheet mills.

The Virginia Bridge and Iron Company, of Roanoke, W. Va., will erect a plant in Memphis, Tenn.

The Standard Mutual Works Company, Thompsonville, Conn., is erecting another shop building.

Williams Brothers, of Peoria, Ill., will erect a plant in Seattle, Wash., for the manufacture of woodenware.

F. A. Strauss & Co., Trenton, N. J., manufacturers of worsted yarn, will erect two additions to plant.

The McCrum-Howell Company, Norwich, Conn., manufacturing ranges and boilers, is enlarging plant.

The Nagle Engine and Boiler Works, Erie, Penn., has started the erection of the $50,000 addition to plant.

Willis & Son Co., sheet metal workers, Moline, Ill., will move to larger quarters and install additional machinery.

The American Railway Appliance Company, of Oil City, Penn., has decided to locate a plant near Tonawanda, N. Y.

The Minneapolis (Minn.) Gas Traction Company is erecting a $35,000 addition to plant at University and 28th avenue.

The Wells-Sapulpa Packing Company, Sapulpa, Oklahoma, has let contract for the construction of a $250,000 packing plant.

The Charlotte (N. C.) Mantel and Novelty Company will establish plant for the manufacture of mantels, office fixtures, etc.

Contract has been let for the erection of factory building for the American Wheel Company, Elkhart, Ind., a recently organized concern.

The Watson & McDaniel Co., Philadelphia, Penn., manufacturing steam specialties, has awarded contract for the erection of a new factory.

It is reported that the Midway Lumber Company, Seale, La., will establish a plant at Beaumont, Tex., for the manufacture of boxes, packing cases, etc.

The Boston Confectionary Company will install in plant at 817 Main street, Cambridge, Mass., a 200-horse-power gas engine and other necessary machinery.

The Wood Electric and Manufacturing Company, South Bend, Ind., is erecting an additional factory to be devoted to the manufacture of the Wemco gasolene engines.

The Forshee Manufacturing Company, Dayton, Ohio, which makes household articles of tin, steel and galvanized iron, will move to a larger plant, increasing its output.

Col. E. A. Wall and Reuben May, owners of the Salt Lake (Utah) Engineering Works, will erect a plant for the manufacture of steel castings. This is to cost $50,000.

Spear & Riddel, Wheeling, W. Va., now making carriage axle machines and washing machines, will engage in the manufacture of automobile parts, specialty axles and steering knuckles.

The Trenton (N. J.) Machine Specialty Company has just completed erection of new plant at 50-52 Parker avenue, consisting of machine and blacksmith shop, drafting room and pattern shop.

The Michigan Brass and Iron Works, Lansing, Mich., will erect a new foundry for the manufacture of gray, iron, brass and aluminum castings. This concern is successor to the Walker & Schultz Foundry Co.

The Eastern Wisconsin Traction Company, Fond du Lac, Wis., is planning to abolish line shaft and charge to direct-connected generators. Will change from 8000-volt series direct-current to 660 volts, seven lights in series.

The Puget Sound Iron and Steel Works, Tacoma, Wash., is erecting a new plant for the manufacture of hoisting and logging engines and marine engine construction and repair. This will consist of machine shop, foundry, forge shop and pattern shop. Catalogs of modern equipment are requested.

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open the following bids: May 18—Oxygen-acetylene welding and cutting plant (schedule 1218); May 25—hydraulic reversible gears (schedule 1225), pipe fittings (schedule 1241), recoil springs (schedule 1237), blanks, keys, hinges, locks, screws (schedule 1240); track drills, tools, steel wheelbarrows (schedule 1234); condensing equipment (schedule 1227), concrete mixer (schedule 1224), propelling machinery (schedule 1226), steel casting, structural steel (schedule 1236), steel, tool steel (schedule 1238), cars, rails, supplies (schedule 1234); steam locomotive (schedule 1223); June 1—blueprint paper, locks, tinning solder, corrugated s eel (schedule 1231); steel bolts and nuts, boiler tubes, copper tubing (schedule 1232).

New Incorporations

The Gem City Stove Manufacturing Company, Quincy, Ill., has been incorporated with $175,000 capital. Incorporators, W. H. Heibreder, L. C. Zander, W. H. Govert.

The Hercules Wheel Company, Evansville, Ind., has been incorporated with $75,000 capital. Wm. H. McCurdy, president. Will manufacture wheels for all purposes.

The New York Metal Products Company, Newark, N. J., has been incorporated with $50,000 by H. M. Short, Summit, N. J. M. Watson and C. H. Watson, New York.

The Empire Machine Company, Jersey City, N. J., has been incorporated. Capital, $800,000. Incorporators, B. S. Mantz, John R. Turner, L. H. Gunther. Will manufacture machinery.

The Chicago Rival Machine Company, Chicago, Ill., has been incorporated to manufacture and deal in machinery. Capital, $10,000. Incorporators, Willis H. Hutson, John E. Erickson, Rex G. Hardy.

The Freeport Windmill and Engine Company, Freeport, Ill., has been incorporated to conduct a foundry and machinery business. Capital, $30,000. Incorporators, Oscar J. Ziegler, Roy M. Bennethum, Fred L. Kobow.

The Duroth Manufacturing Company, Seward, Penn., has been incorporated with $50,000 capital to manufacture car wheels, mine and railroad supplies, on patents secured by Mr. Duroth, who is president of the concern.

The Plainfield Auto Sales Company, Plainfield, N. J., has been incorporated to manufacture and deal in automobiles, autocars, supplies and fixtures. Capital, $25,000. Incorporators, C. C. Brown, C. C. Rocap, Dr. S. A. Aldrich.

The Bartlett-Hayward Company, Baltimore, Md., has been incorporated to manufacture gas and heating apparatus, structural and ornamental iron work. Capital, $1,500,000. Incorporators, E. Bartlett Hayward, D. E. Conklin, Howard Bruce, etc.

New Catalogs

Industrial Instrument Company, Foxboro, Mass. Bulletin No. 22. Standard electric type systems. Illustrated, 40 pages, 8x11 inches.

Baxter D. Whitney & Son, Winchendon, Mass. Catalog of edge-shaping machine and gage lathe. Illustrated, 24 pages, 5½x8 inches, paper.

Want Advertisements

Rate 25 cents per line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E. G. Smith, Columbia, Penn.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Hand power bending tools, labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Light, fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

A large foundry and machine shop desires to add to present lines of manufacture. Box 126, AMERICAN MACHINIST.

Special machinery accurately built. Screw machine or turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

Machines designed; automatic, special. Practical working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia, Pa.

Light and medium weight machinery and duplicate parts built to order; tools, jigs, etc. MacCordy Mfg. Co., Amsterdam, N. Y.

Fully equipped machine shop will manufacture models on contract or day work. Menchen, 360 West 50th St., New York City.

Capital for a promising manufacturing proposition. Party interested can be given an opportunity to invest in something that will grow. Box 207, AMERICAN MACHINIST.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMERICAN MACHINIST.

We want a machine shop; also, one or more thoroughly practical machinists, with some money to take an interest in such an enterprise with a local party and manage the business. For further particulars, address Business Men's League, Clarendon, Ark.

Proposals for Ordnance Supplies—Watervliet Arsenal, Watervliet, N. Y., April 17, 1909. Sealed proposals in triplicate will be received until 1 p.m., May 17, 1909, for furnishing iron, steel, hardware, forage, fuel, oils, etc., during year ending June 30, 1910. Information furnished on application. Lt. Col. W. W. Gibson, Comdg.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Toolmaker and designer with wide experience on jigs, tools, fixtures, gages, special and automatic machinery; 12 years on sheet metal work, who could handle men to advantage, wishes foreman's position. Box 195, AMER. MA.

Young man with technical training, three and one-half years as machinist and two years drafting room experience, desires a change. Wishes a position which affords a chance for advancement. Address "A," P. O. Box 357, South Norwalk, Conn.

INDIANA

Wanted—Position as foreman; A-1 machinist and diemaker; large experience in foremanship; thoroughly understands punch presses; successful organizer; now employed, wishes to make a change. Box 181, AMER. MACH.

MASSACHUSETTS

Who will pay $4.50 per day for a good foreman toolmaker? Box 183, AMER. MACH.

Mechanical graduate, 31, married, four years' shop, four years' drafting and superintending, inventive and energetic, desires responsible position in Middle West. Good references. Box 193, AMERICAN MACHINIST.

Mechanical engineer, European graduate, with thorough theoretical knowledge, experienced designer for steam turbines, turbine air compressors and turbine pumps, seeks responsible position. At present with first class manufacturing concern. Opportunity of introducing the above machines desired. Box 198, AM. MA.

MICHIGAN

I want to correspond with a growing concern needing the services of an experienced man on tool or die work, as foreman or superintendent; have thorough knowledge of modern methods of producing duplicate parts economically. Box 200, AMERICAN MACHINIST.

NEW JERSEY

General foreman, excellent toolmaker and machinist, designer of labor-saving devices, open for engagement. Box 182, AM. MACH.

Expert designer automatic machines, experienced in drawing room and shop management, wants responsible position. Box 216, AMERICAN MACHINIST.

NEW YORK

Draftsman, designer, experienced, seeks position. Box 191, AMERICAN MACHINIST.

Designer of special machinery and general manufacturing plant equipment. Eight years' shop and office experience. Box 197, AM. MA.

Mechanical draftsman with broad experience in gas engine, automatic machinery

and automobile design, wants employment. Box 209, AMERICAN MACHINIST.

With eighteen years' experience; can give first-class service as draftsman or shop foreman; technical education; cost reducing; good work. Box 201, AMERICAN MACHINIST.

Responsible position desired by an all-around mechanic; first-class designer and draftsman; thoroughly experienced; good executive. Will go anywhere. Box 203, AM. M.

Engineer, 28 years old, technical graduate, desires position as assistant engineer, assistant superintendent or chief draftsman in automobile, or gas-engine industry. Box 215, AMERICAN MACHINIST.

Draftsman, graduate M. E., age 31, experienced designer fine apparatus, small devices, special machinery, fixtures, experimental work; very able man. Box 213, AMERICAN MACHINIST.

Superintendent—Mechanical engineer, 35 years old, experienced in refrigerating, gas engines, oil engines and automobiles, shop, drawing room and office experience, excellent references, open for position at once. Box 212, AMERICAN MACHINIST.

Works manager, American, technical, experienced; age 36, at present employed, desires to change. A former associate says, "If you wish an aggressive man who will use improved methods in order to decrease cost of output, will require a faster pace from foremen and workmen, will not hesitate to make special tools when the saving in cost of production will pay large return on the investment, he will fill the bill to your entire satisfaction." See also my ad. in last week's issue. Address "Production," Box 202, AMERICAN MACHINIST.

OHIO

First-class planer hand wants responsible position. Capable of handling gang of men with good results. Box 217, AM. MACH.

PENNSYLVANIA

Draftsman, college graduate, experienced. A-1 reference. Box 198, AMERICAN MACHINIST.

Superintendent with established reputation for getting maximum production, at minimum costs, would like to consider a change; good reasons given. At present successfully engaged as superintendent of well known concern, manufacturing most intricate and highest quality product, where interchangeability is absolutely necessary; 39 years of age; an American and a hustler; wide experience in factory organization and piece work systems. Box 195, AMERICAN MACHINIST.

VERMONT

Wanted—Position as cost clerk by young man who has had experience on printing presses, steam heaters, boilers, electric cars, general machine and foundry work; well informed on card systems. Box 214, AM. M.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Wanted—Six first-class die makers on buckle work. Permanent positions for good men. Apply to Gilbert N. Bassett Co., Derby, Conn.

ILLINOIS

Wanted—First-class man to take charge of crank-grinding department; references required. State salary wanted. Good and permanent position to capable man. Box 210, AMERICAN MACHINIST.

Wanted—Cost clerk and estimator in office of a Chicago concern manufacturing miscellaneous machinery. In replying state fully experience and previous employment, also salary expected. Box 204, AMER. MACHINIST.

Wanted—Mechanical engineer, draftsman and designer, exclusively for building presses, automatic machinery and dies for sheet-metal work. State experience and give references. Location Middle West. Box 211, AM. MACH.

INDIANA

Wanted—Good all-around machinist; must come well recommended. Address F. W. Freese, Ft. Wayne, Indiana.

MICHIGAN

Wanted—Good operators on National Acme automatic machines. Will pay good wages to first-class men. Also two or three good Potter & Johnston operators. Cadillac Motor Car Co., Detroit.

First-class cost man for automobile axle factory. Wanted only good man of experience in this line of work. Good chance for advance in position and salary. Box 199, AMER. MACH.

NEW HAMPSHIRE

Wanted—A young man about 25 years of age with technical training and good experience on machine manufacturing, who has had charge of help, to act as assistant in machine shop on small interchangeable work. Good chance for advancement for the right man. Box 163, AMERICAN MACHINIST.

NEW JERSEY

Wanted—Three first-class die makers experienced on sub-press dies, light and medium size sheet steel work. New tools. Good wages. Steady work for the right men. Address "Supt.," Box 476, Newark, N. J.

We want a good all-around machinist as general foreman, one who can become financially interested preferred. Factory located near New York City, manufacturing automobile engines and gears. Address "Reliable," AM. MA.

Wanted—A first-class machinist, who has had experience, preferably on high-speed steam engines, and who has either been a working or general foreman. Give references and wages desired. Box 178, AMERICAN MACHINIST.

Wanted—An instructor in patternmaking, woodturning and carpentry at an Eastern technical school. Must have had good experience, good general education, be of excellent character, and possess ability for imparting information. State age, nationality and references. Box 196, AMERICAN MACHINIST.

In our rapidly growing business of the manufacturing of a well known article, we always have openings for draftsmen and toolmakers on small tools, jigs, sub-press dies and special machinery. We invite applications from first-class men on this kind of work. Box 884, AMERICAN MACHINIST.

NEW YORK

Wanted—Mechanical engineer, wide-awake capable young man of 30; must be good detailer and familiar with bonus or premium system. Box 208, AMERICAN MACHINIST.

Designing draftsman wanted, experienced on fine tool, gage, jig and fixture work. State age, experience in detail and salary expected. Box 205, AMERICAN MACHINIST.

Toolmakers wanted—Several first-class men experienced on fine tool, gage, jig and fixture work. State age, experience in detail, and wages expected. Box 206, AMER. MACHINIST.

Man to take charge of department in large forge shop. Must have broad experience on general forging and heading machinery, and be a good handler of help. Give experience in full. Address "M. M.," AMERICAN MACH.

Wanted—A first-class mechanical draftsman and engineer, with long experience in designing very large machinery of the most accurate description. Fine position for the right man. Address immediately, G. W. Ritchey, Park Avenue Hotel, New York City.

Man wanted to take charge of the machines in a machine shop employing about one hundred hands, to increase output, under the general orders of the department foreman; must have broad experience and be a good and aggressive handler of help. Give full particulars. Applications confidential. "Y. W. X.," AM. MA.

Wanted—A first-class, all-around machinist with a thorough knowledge of the possibilities of high-speed steel for general use on lathes, planers, monitors and milling machines; one who can get the best results therefrom and be able to show others. Give experience, references, age and salary expected. Address P. O. Box No. 1013, New York.

Wanted—Foremen for sheet metal department of large automobile factory, man capable of handling at least 100 men and able to devise methods and fixtures for rapid production of automobile bodies, fenders and tanks. Need not be a man with wide experience in metal stamping, but must be a hustler and have executive ability. Unless you have held similar position before do not apply. Address "Sheet Metal," care AMERICAN MACHINIST.

OHIO

Wanted—Machinists accustomed to work on Corliss engines and pumping machinery. The Heisler Company, St. Marys, O.

Wanted—High grade foundry superintendent for machine-molding gray iron foundry; building and equipment new and up-to-date. Present daily capacity, 35 tons. A splendid opportunity for an advanced practical foundryman; exemplary character, good habits and executive ability essential. State full particulars, present salary and references. Address "Superintendent," Box 200, AMERICAN MACHINIST.

WISCONSIN

Wanted—Mechanical draftsman, who was primarily a shop man; must understand the production of intricate and interchangeable parts cheaply and accurately; must be good jig designer and be able to detail practical ideas to the finished product. State age, experience and salary expected. Box 190, AM. MA.

For Sale

For Sale—26-horsepower special "Foos" gasolene engine with 38"x10" clutch pulley. In good condition. Address F. W. Freese, Ft. Wayne, Indiana.

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Interesting Methods in the Thomas Shop

Setting and Boring Cylinders, Fixtures for Crank Cases, Cam Shafts, Gisholt Lathes and Grinders and an Interesting Device for Testing Springs

EDITORIAL CORRESPONDENCE

Everyone who followed the struggles and the final victory of the Thomas car in the famous New York to Paris race, and this means anyone who hasn't an ingrowing grouch against all "benzine buggies" on what passes for principle, will be interested to know something of the methods used and the tools and men behind the car. The factory lies almost on the bank of the Niagara river and is on the site of the old Cleveland property, being occupied by Grover Cleveland when his was a local instead of a national name. The old house is still standing, surrounded by shop buildings, but must soon come down to make way for more factory buildings.

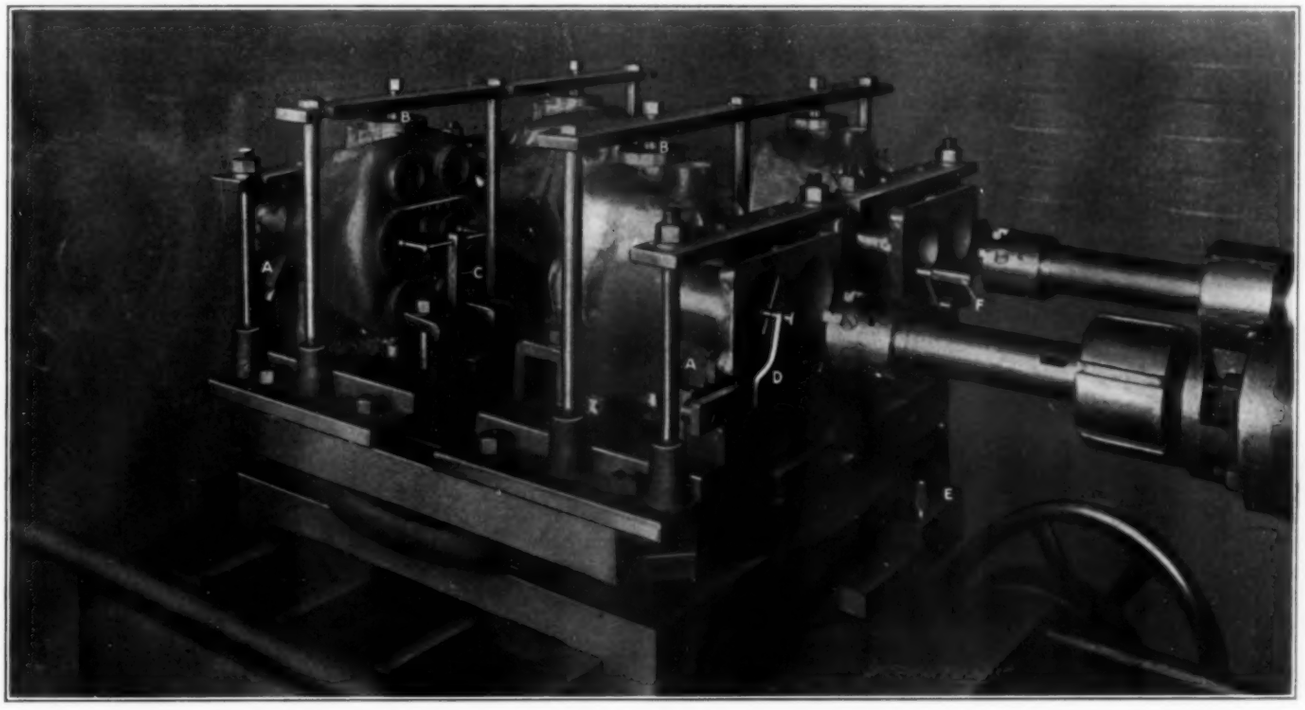


FIG. 1. FACING AND BORING THE CYLINDERS

Centering the Cylinders

The cylinders are machined on the special Beaman & Smith boring and facing machine shown in Fig. 1 being held in a substantial fixture on the turntable mounted on the cross slide. The cylinders are centered by the bore and from both ends, by the use of a target gage *C* at the back and a very ingenious system of scribing indicators in front. The fixtures have a groove planed in the bottom central with the cylinder castings and midway between the two cylinders. A tongue in the bottom of the target gage fits in this and centers it so that both targets can be used in setting the upper or back end of the cylinders.

On the front of the fixture, in front of the cylinders, are two pins in line with the centers of the cylinders. A fixture *D*, having three holes spaced the same as the pins, and an arm over the center hole, carries a scriber at the upper end of this arm which swings at a point just at the center of the cylinder. Placing this fixture on the pins and swinging the scriber by the nurled thumb nut at the outer end, shows at a glance just how the bore of the cylinder is lined up, comparing this with the targets at the other end of the cylinder, and insures the bore being set straight so as to cut out an equal amount on each side.

Moving the fixture *D*, to the right, brings the third or left-hand hole over the left-hand pin and centers the scriber for the other cylinder and shows whether this is also central. Should the casting be a trifle out, bringing the cylinders at slightly varying center distances, the casting can be moved so as to divide up the error to the best advantage.

The cylinders are held by the jaws *A A* which grip around the unjacketed portion of the bore, and also by the pads *B B* which fit on the side openings in the cylinders. They are first faced off by the large milling cutter at the back side, then swung around to be bored, first with roughing and then with finishing boring bars.

After boring the first pair of holes, the pin *E* is pulled out, the whole carriage moved across the bed to the other hole, the pin put in place and the second pair of cylinders are in position to be bored. The depth of the bore is measured by the gage shown in place at *F* and to be described in detail in a later article. A steel plate is laid top of the pins that hold the scribing fixture and the gage worked from that. All told the cylinder boring is a very interesting operation and all future operations are worked from the bore of the cylinder instead of from the bolt holes as in some shops.

Crank Case and Milling Fixtures

Two jigs for the crank case are shown in Fig. 2, one for drilling and the other for boring the main holes including the cam-shaft bearings. The method of holding the crank case by the trunnions at the end, is readily seen. The drilling jig needs little description, the whole case being swung on trunnions from the ends, indexed by the pin at the right for dif-

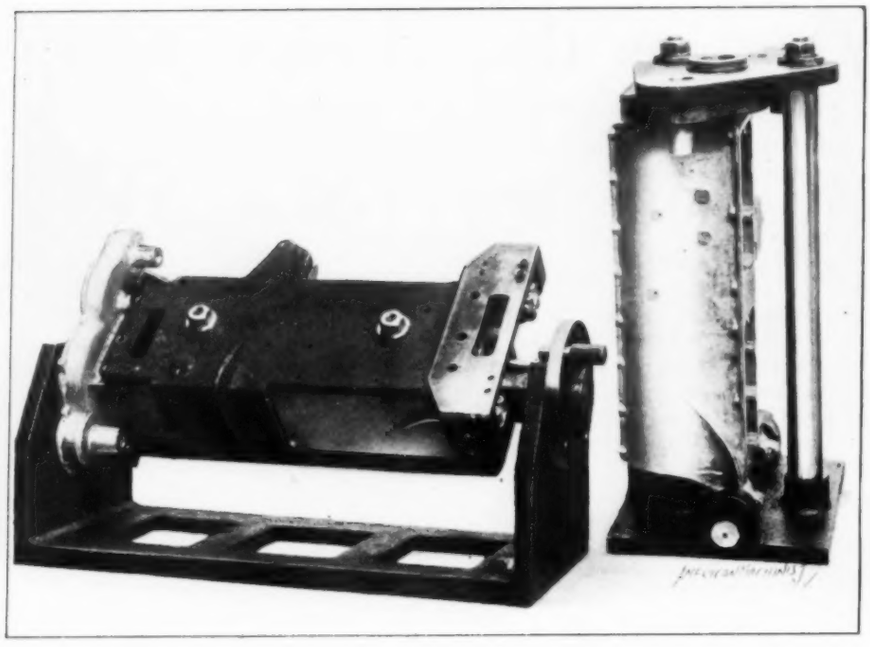


FIG. 2. DRILLING AND BORING JIGS FOR CRANK CASE

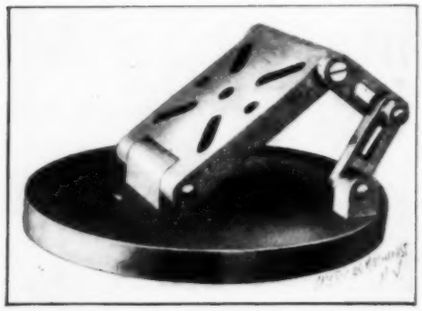


FIG. 3. ADJUSTABLE ANGLE PLATE

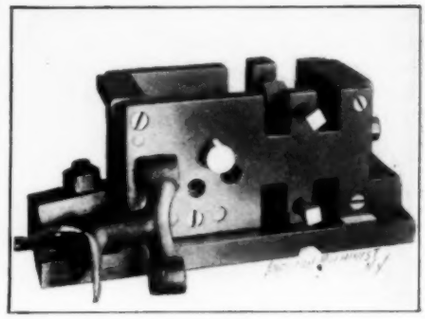


FIG. 4. REVERSIBLE MILLING FIXTURE

ferent positions, and all the drilled holes taken care of in this way. This is a handy way of supporting the work where holes are to be drilled on different sides and at different angles and has advantages over rolling the whole jig, including the base, for this purpose. This means much more work and less accuracy than trunnions, unless the equivalent of having the whole jig round, is used as has been shown from another shop.

Fig. 3 shows an adjustable angle plate that is used to considerable extent in the Thomas shop, being equally applicable to the lathe or milling machine. Its action and uses are both plain.

An unusual milling fixture is shown in Fig. 4 which is for milling the arms or wings on the bracket shown in front. The fixture consists of the hollow box and the base plate, having one fixed lip at the right and the clamping dog at the left. The bracket is placed in the box in the position shown, the angle portion fitting into position, and is held down by the pin *P*. The wings to be milled are centered and held against side movement by the set screws shown and the whole fixture fastened to the milling-machine table so that the straddle mills can pass through the slots and mill both sides of a wing at once. Then the clamp is loosened, the whole box turned over and the projecting ends fastened to the base, which places the second side in position to be milled to correspond to the first.

Locating Keyseats for Cams

On some styles of motors the cams which operate the valves are made separately and keyed on the shaft and in others they are cut solidly on the shaft itself. In Fig. 5 is a fixture for cutting the keyseats in shafts of the first order on a hand-milling machine. This fixture consists of a long table bolted to the main table of the machine and carrying a long indexing bar in four bearings, while the cam shaft itself is supported by a fifth bearing directly under the milling cutter. This requires a bushing cut away at the top as shown to the left of the shaft bearing. The shaft to be cut is fastened in the end of the indexing bar which is controlled by the head at the right. After one keyseat is cut, the index pin is withdrawn, the bar moved to the next one and the operation repeated. This is continued until all the keyseats are cut, turning the indexing bar and the work to the other set of holes to get the location of all the cams. The cutter is fed down into the work to a stop and when end movement of the carriage is necessary it is controlled by the stops on the side of the carriage.

The grinding of ball races is done with a neat indexing head put on a small cutter grinder as shown in Fig. 6. The base is graduated all the way round to se-

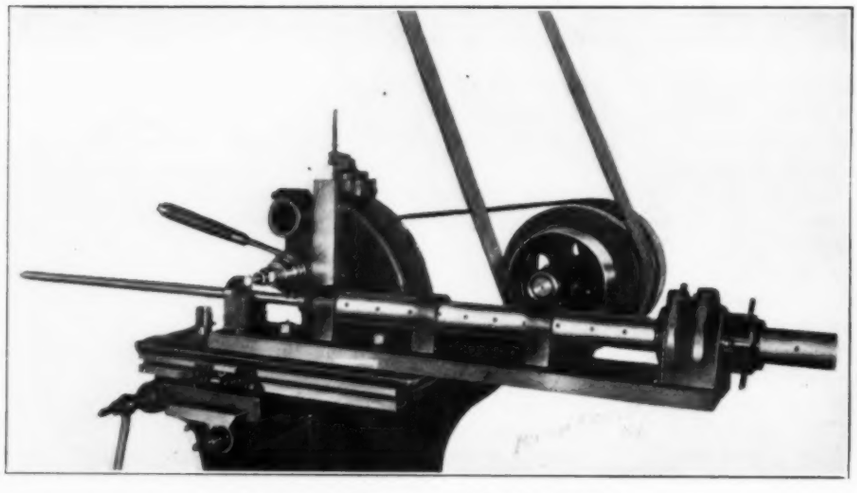


FIG. 5. KEYSEATING THE CAM SHAFTS

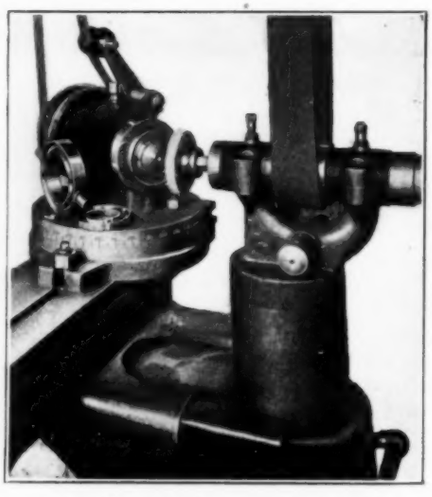


FIG. 6. GRINDING THE BALL RACES

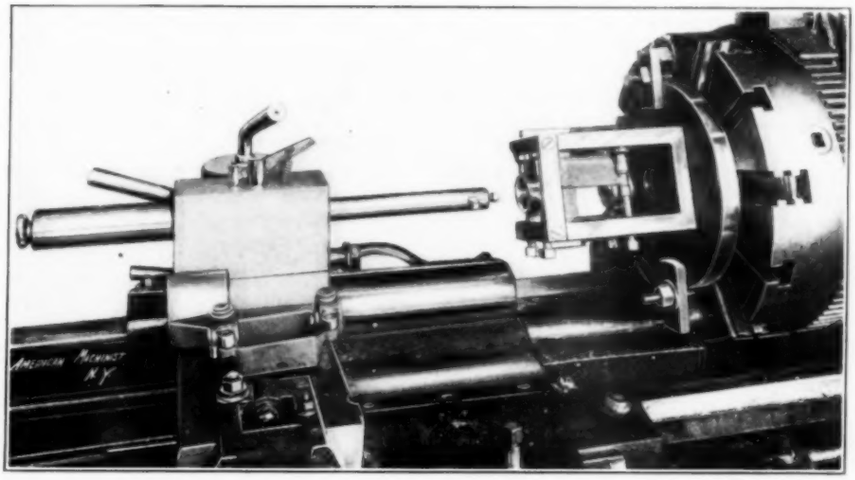


FIG. 7. FIXTURE FOR FACING ON A GISHOLT

cure any angle desired for the races. The races are held on an expansion chuck and revolved while being ground by an independent belt. The head is swung so as to feed the work across the edge of the wheel by moving the whole slide in and out from the column.

INTERNAL FACING ON A GISHOLT LATHE

An application of the stop system to the Gisholt lathe is seen in Fig. 7 in which a substantial block is mounted on the cross slide and through this the facing bar passes, held from turning by a key in the keyway and indexed by stops going down into the top of the bar. The work is shown in front of the tool slide which is a double bearing and has four faces to be finished. The facing cutter in the end of the bar is run into the work to a stop, the facing done by a cross movement until the cross slide stops. After withdrawing the bar is moved to the next hole, the carriage being fixed during these operations, and the others faced at the same setting. The work is held in the box fixture and is bored by a regular boring bar before the ends of the bearing are faced.

A handy form of indexing fixture for a hand-milling machine is shown in Fig. 8, made in the form of a turtle's back. It carries a double set of collets, one inside the other. The work is held in these and is indexed by the handle beneath and the stop pin at the left. It is an old principle but rather an unusual application and will be found useful in many places.

An unusual method of holding jigs on the work to be drilled is shown in Fig. 9 and is known as the spring holder. The example shown is not an actual case, being rigged up in haste for the photographer. In actual use the drilling jig and work bear such relation to each other that they are easily placed in their correct position and then are both pushed under the spring which holds them in place while being drilled. In many kinds of work this plan can be used to advantage and the time required is very little as compared with any kind of a clamping fixture.

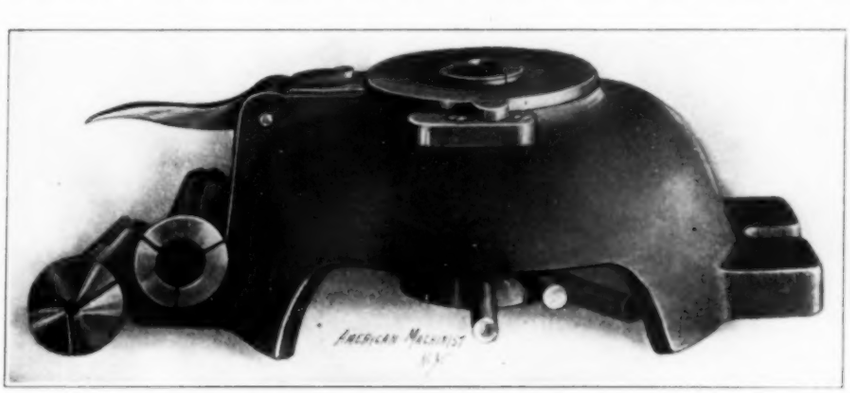


FIG. 8. INDEXING FIXTURE FOR HAND MILLER

THREE INTERESTING TOOLS

Fig. 10 shows three rather interesting tools. The one at the top is a boring tool for jig work on the milling machine which is a little out of the ordinary. The bar is held in the triangular shank which in turn is pivoted in the head of the driving shank. This head carries two set screws which adjust this triangular piece and the boring tool with it, so as to secure any desired adjustment of the boring-tool point.

The fixture at the left is an ingenious method of drilling the two holes at the end of a slotted keyway. The plain block is bored to fit the bar to be drilled and this is held in place by the set screw at the side. The novel part is in the bushing above which controls the drill and the location of the holes. The hole in the bushing is drilled enough out of center so that when turned half way round, the second hole drilled will be at the other end of the keyway. In other words, the eccentricity is one-half the length of the keyway or the distance between holes. Then the bushing is slipped into place and held by the spring latch at the side, and after the first hole is drilled, the bushing is pulled out, turned half way round and slipped back so that the latch holds the other notch and the hole at the other end of the keyway is drilled. The latch indexes the bushing and there is no trouble in drilling the holes in just the positions desired.

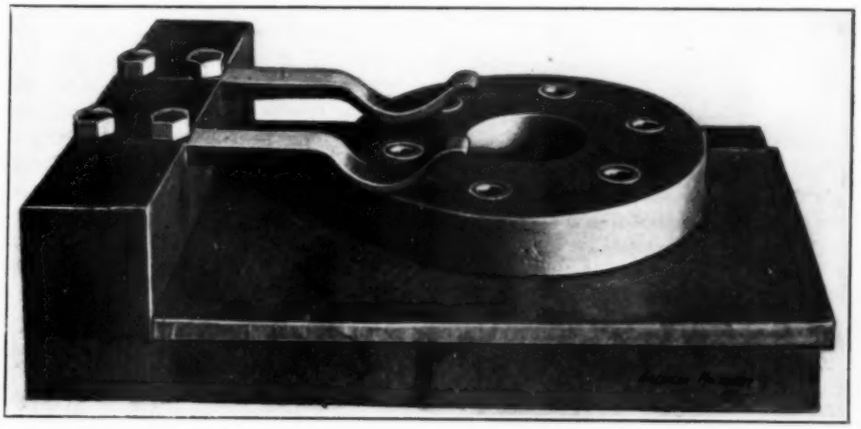


FIG. 9. SPRING JIG HOLDER

The third instrument is an indicator for showing the amount of compression space in the cylinder, between the end of the piston and the cylinder head. The outer ring is loose on the inner or indicating part and screws into the valve-chamber opening. This brings the arm at the side over into the cylinder bore, through the port opening, so that the piston head strikes it as it comes up and indicates on

the scale above. The pointer is adjustable and after being set for any given condition this instrument will show at once the compression in any engine in the lot. While this is not used in regular inspection work it is convenient on special occasions.

rying the ends of the spring as it is forced down by the air cylinder above it. This air cylinder is fastened to the column as shown and is adjustable vertically by the screw and hand wheel on the vertical bars. Air pressure comes in at the top and forces the piston down which com-

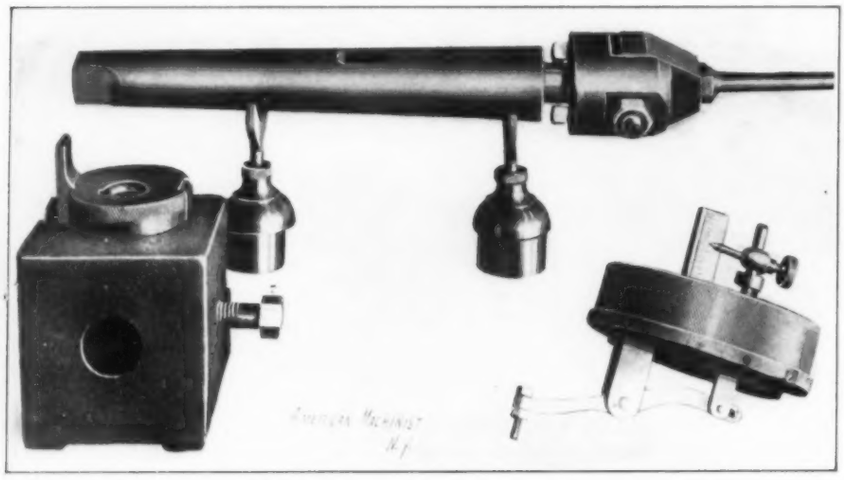


FIG. 10. THREE HANDY TOOLS

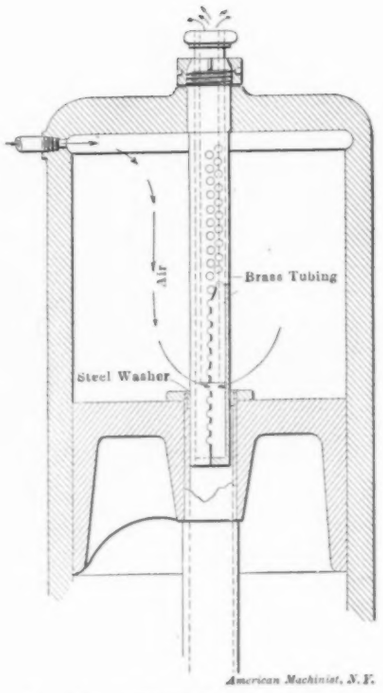


FIG. 13. INTERIOR OF AIR CYLINDER

The Spring-testing Machine

The testing of the springs used in automobile construction is usually a matter of some uncertainty or at best not a convenient operation, so Mr. Buxton designed the apparatus shown in Figs. 11 to 13 for this purpose. First of all is a platform scale with a channel iron track on a beam which lies diagonally across it, and in which two small trolleys run, carpresses the spring and runs the ends out on the small trolleys. Fig. 11 shows the scale beam down and in Fig. 12 the spring is compressed and the weights are raised.

This is controlled by a perforated pipe which runs from the top cylinder head down into the piston rod as shown in Fig. 13. Inside of this tube is another which is a snug fit in it and is not perforated. This inner tube controls the travel of the piston by preventing the escape of the air until the piston has traveled far enough to uncover the perforated holes in the outer tube, beyond the end of the inner tube and allow the air to escape through the tubes and out at the top. Moving the inner tube up or down controls the air perfectly and accurately determines the load which will be put on the springs. The load is weighed in each case by the scales

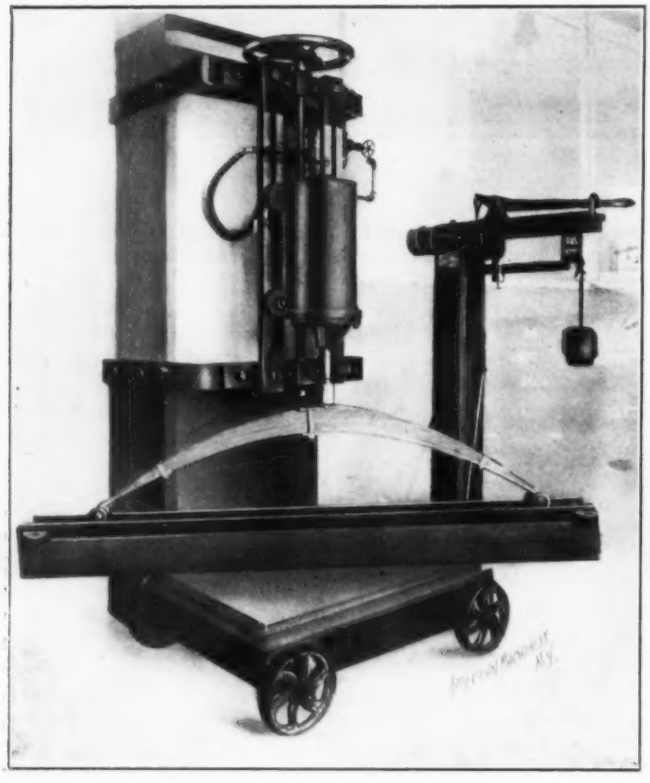


FIG. 11. SPRING READY TO TEST

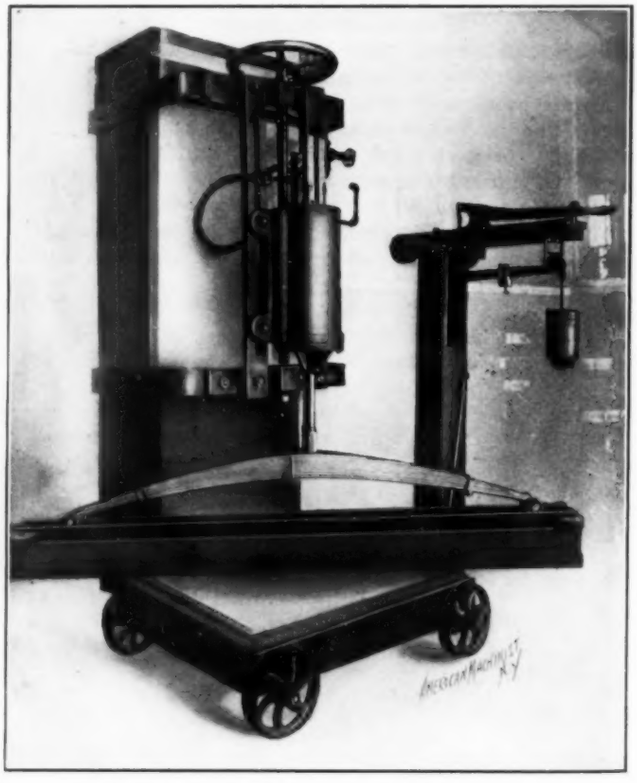


FIG. 12. WITH THE LOAD ON THE SPRING

and this device in the cylinder controls the travel so accurately that the springs can be tested very rapidly and with the assurance that they all have the same compression.

Most of the interesting devices shown with this belong to either the production manager, C. B. Buxton, or the tools designer, L. L. Haas, as well as some very interesting gages and fixtures which will appear in a later article. We are also indebted to Mr. Nehrbaus, the general superintendent for his assistance and cooperation. F. H. C.

Cutting and Piercing Punch and Die

By Henry Percival

The drawings illustrate a punch and die designed for cutting and piercing the mild-steel blanks shown in Figs. 1 and 2. The blanks vary in length from 2.7 to 7.5 inches, and are cut from strip, which is delivered to the press shop ready-rolled to the required width, and in coils to facilitate feeding into the machine.

The Die

Fig. 3 is a plan, and Fig. 4 a sectional elevation of the bottom tool. The die *A* is made in two parts, each half being a duplicate of the other, and is entirely machine-finished. The outline of the die is milled with a standard concave cutter, the vise holding the blank being tilted ½ degree to give clearance to the cutting edge. As the die is ground down in use, the punch, on account of the clearance in the die, becomes a poor fit. This is corrected by grinding the faces *a a*, Fig. 5, and so closing the die on the punch. This method of construction gives the die a long life without the expense in time and labor that would be required to work the punch through a solid die. Further, the correct outline is maintained throughout at the cutting edge. The piercing holes *b b* are given clearance by reaming from the back with a D-reamer having an included taper of 1½ degrees. The two parts of the die are registered by a short dowel in the hole *c*, Fig. 5.

The faces *a a* are left higher than finally required so that after hardening they may be ground to a true face. In hardening, the two parts are wedged together in a special clamp, so as to reduce the tendency to warp. Hardening the two together also insures their being of the same temper.

How the Die is Held

The sides of die *A* are at an angle of 78 degrees and are held together in the bolster *C* by the mild-steel cotter *B*, as shown in Figs. 3 and 4. The cotter *B* is locked in position by the nut and washer shown, and each end is hardened to prevent any upsetting when it is driven in or out.

This method of holding a split die makes a very solid job, and although when new, this die stands out of the bolster nearly as far as it is within, we have never had any trouble through the die opening. The pin *d* is for locating one end of the die in the bolster; *e* is a hardened tool-steel block, which is held in a dovetailed slot *j* by the round-headed screw shown. This block acts as an anvil for a stamp (not shown), which is held in the top tool and marks each blank as it is cut.

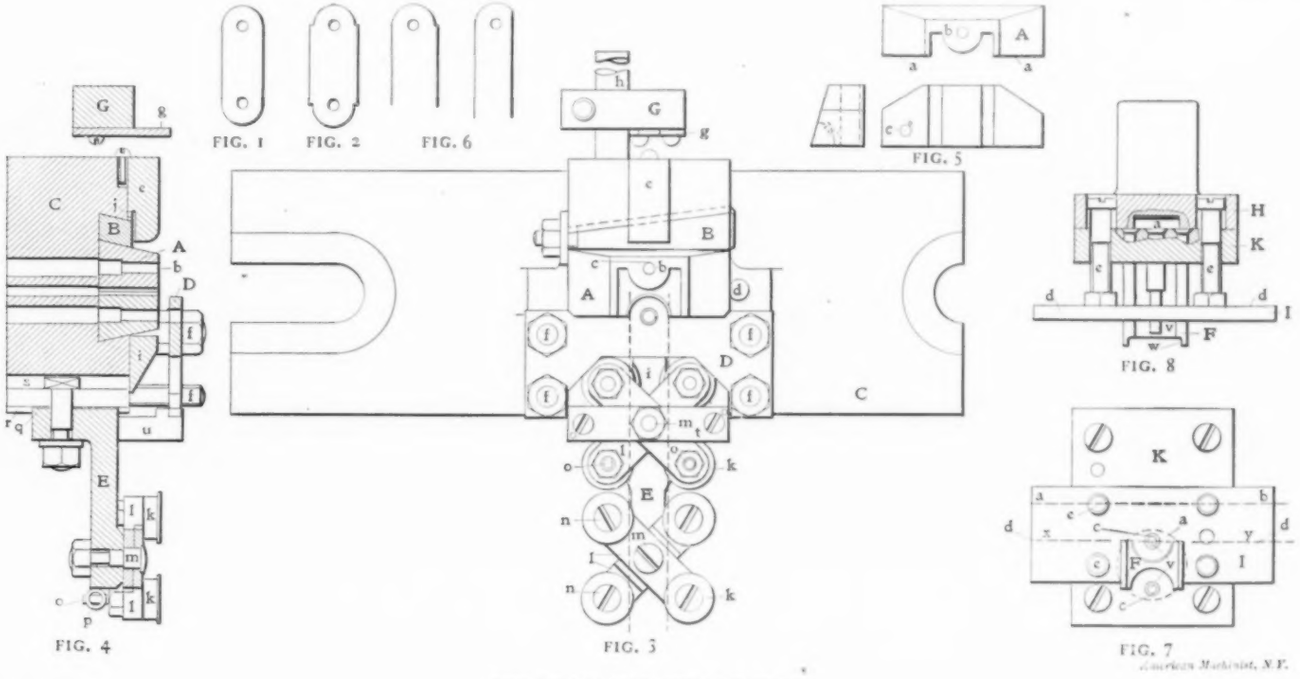
Stamping in an ordinary press as a practice is, I think, to be condemned, as with the ordinary variations in thickness of commercial stock, too much shock is given to the crank, unless the press has a surplus of power. In this case special circumstances warranted our going "agin the Government."

The Bolster

The bolster *C* is of cast iron and was made from an existing pattern, one end being sawed off to enable the tool to be put in a Brown & Sharpe surface grinder for grinding the die without removing the studs *f f*. Two nuts on each of these studs hold the fixed stripper *D*, and allow its position to be adjusted as the die is ground down. In Fig. 4, for clearness, one of the studs is shown without nuts. *G* is an adjustable stop of mild steel sliding on the rod *h*, and having a hardened tool-steel face *g*, which is adjustable vertically. A block *i* is held in a dovetailed slot, which is a continuation of that holding the anvil *e*, it being milled at the same time. The purpose of this block is to guide the strip under operation when it is pushed in over the die. It is ground down with the die *A*, as is the anvil *e*.

The Stock Guide

The strip is guided onto the die by the rolls *k k* of the self-centering device shown at the bottom of Figs. 3 and 4. This part of the tool consists of a cast-iron bracket *E* on which are centered two pairs of arms *l l* moving on pins *m m*. The front set of rolls is hung from the bridge piece *t*, which is doweled to two arms of *E*, one of which is shown at *u*, Fig. 4. In



THE PRESS TOOLS AND THE WORK

this view the front set of rolls is omitted for the sake of clearness. At the extremities of each pair of arms *l l* are provided flanged rollers *k k*, as shown. These rollers run on pins *n n*, which are screwed into the arms and locked by nuts; the two rear pins in each set of rolls are longer than the others, and on the projecting arms *o o* are slipped the ends of a closely wound spiral spring *p*. These springs are not shown in Fig. 3, but one may be seen in section at *p*, Fig. 4. The springs *p* draw the rollers together, causing them to bear on the strip when pushed through, as shown by the broken lines in Fig. 3. The centers of the rolls on the same arm being equidistant from the center pin *m*, that portion of strip in each set of rolls is held central over the pin, so that by having the two pins *m m* in line with the center of the die, the strip, if straight will be guided centrally over the die, whatever its width, within the limits of the tool. This saves time that would be necessary to set a fixed guide. The bracket *E* has a tongue *q* which fits in the keyway *r*. *E* is clamped to the bolster *C* by a bolt working in the T-slot *s*. By this means the rolls are kept in position laterally while admitting of adjustment vertically. Although it is not as simple as another method we have of keeping the hole and rounded end central, it is shown as a useful arrangement that may be employed with other forms of dies. It prevents blanks from being made with ends as shown in Fig. 6.

The Punch

A view of the under side of the punch pad is shown in Fig. 7, while Fig. 8 is a section on *a b*, Fig. 7, with a part shown in section on *x y*, Fig. 7. The cutting-off punch is machined to shape, the semi-circular grooves being cut with a standard convex milling cutter. It then requires very little hand work before hardening. The punch *F* and the two piercing punches *v v* are let through a mild-steel pad *K* and riveted over at the back, as shown in the partial section, Fig. 8. In the cast-iron holder *H* is let a hardened tool-steel pad *a* partly shown in Fig. 8, and shown by dotted circle in Fig. 7. But for this pad, on account of the small area of the punches *v v* and *F* part of the holder *H* would be slightly compressed by the punches, and allow them to work loose. The hard pad serves to distribute the pressure over the softer material behind. After forcing the pad in, it is ground flush with the face of the holder. The pad *K* is secured to the holder *H* by the four screws and two dowel pins shown. The end of the cutting-off punch *F* is ground so as to leave two pilots *w w*; these serve to steady the punch and prevent it from shearing the die, should the operator not push the strip right over the opening. As will be seen from Fig. 8, the cutting-off punch does its work before the piercers.

As the tool was first made, the piercing punches *v v* were in advance of the cutting-off punch *F* and just entered the die before the latter started to cut; but after reading the article by Mr. Shlaps at page 881, Vol. 31, Part 1, of the AMERICAN MACHINIST, we altered this as shown. Although it is more trouble to knock back the punch *F* each time it has to be ground, so allowing the wheel to reach the piercers, we prefer to do it to having the piercers in front, as the cutting-off punch appears to last longer after each grinding. We tried having all three level, but found that however carefully the punches were let into the die, the piercing punches wore the worst at points *c c* in Figs. 7 and 3, i.e., farthest away from *F*. This agrees with the theory of Mr. Shlaps that "in starting the separating action the punch pushes the material from it," in which case the piercers, being embedded in the strip, and comparatively slender, are carried against the edge of the die at *c*, Fig. 3.

The Stripper Action

The blank when cut off is lifted on the up-stroke of the press clear of the stop *g* until the floating stripper *I* is arrested by adjustable arms on the press (not shown) which catch on the stripper at *d d*, and so strip the blank from the punch *v*. The press being inclined at 45 degrees, the blank drops behind the stop into a box, and so does not interfere with the strip as it is pushed through to make the next blank. The four screws *e e* carry the floating stripper *I* and slide through the punch pad *K*, the holder *H* being recessed for the heads, as shown in Fig. 8. As the punch is ground down, the position of the stripper is adjusted by these screws, which are locked by nuts shown. The thread on these screws is a fine pitch, as it was found practically impossible to keep the nuts from working loose with the standard bolt thread, in spite of the screws being riveted over. The continual jar of the press was, no doubt, responsible for this. Since using the fine-pitched screws we have had no trouble on this score.

As regards wear and output, this set of tools has been found to stand well, the average number cut at one setting being 25,000, with runs as high as 30,000. On one occasion it did 38,000, though this just about reached the "butchery point." The coils of strip are fed from a reel. Two of these tools keep an operator turning out 3000 per hour feeding by hand.

A Few Railroad Shop Devices

A recent visit to the shops of the Philadelphia, Baltimore & Washington division of the Pennsylvania railroad at Wilmington, Del., revealed a number of interesting details, some of which are illustrated herewith.

The babbitting of a locomotive crosshead is not always an easy job as the babbitt lining is quite thin as compared with the length of crosshead, which adds to the difficulty of having it flow easily and smoothly over the whole surface. Both the crosshead and the mold or jig must,

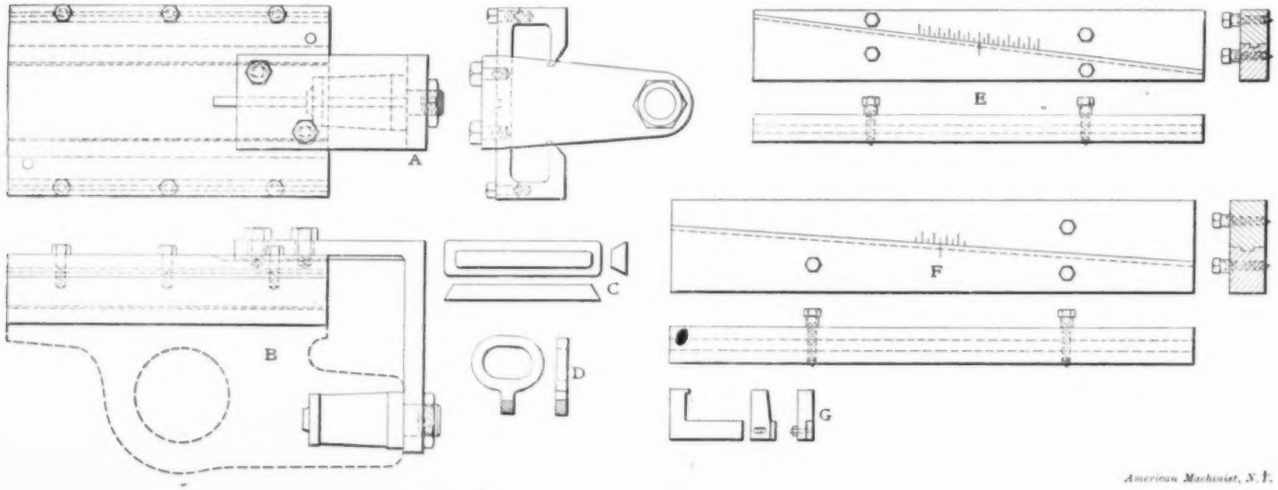


FIG. 1. JIG FOR BABBITTING LAIRD TYPE CROSSHEADS

of course, be heated to secure the best result, but the most difficult part is to center the jig properly without taking too much time in so doing.

The jig shown is one designed for a Laird type of crosshead in which the piston rod is at a considerable distance below the sliding surfaces, and as will be seen in *A* and *B*, Fig. 1, this is located first from the taper hole in which the piston rod seats. The bracket at the end of the jig is adjustable to some extent so that the end of the jig can be brought flush with the end of the crosshead, as indicated at *B*. It must at the same time be centered sideways and the block *G* is fastened at the lower end to prevent the babbitt from running through and out on the floor.

In order to aid pouring into this narrow opening and to prevent pouring it on the end of the crosshead which is uppermost, the block *C*, which has tapering sides, is laid over the end of the crosshead and the metal poured against the slanting side of the block. In the case of crossheads having varying thicknesses of the wings or sliding portions, the babbitting jig is provided with adjustable sides, as shown in *E* and *F*. These join on an inclined surface and have graduations showing where they should be set for the different crossheads. *D* shows screw eyes or handles for lifting the jig from place to place and its operation will be perfectly clear without further description.

An Unusual Blueprinting Arrangement

In the drafting room of the Wilmington shop, which happened to be located on the wrong side of the building to secure the best light for blueprinting, is a somewhat unusual arrangement designed to secure good results under adverse circumstances and again emphasizing the old adage of "necessity being the mother of invention."

Fig. 2 shows a section of the blueprinting room with its somewhat peculiar skylighting and hood. Under this are two uprights made of piping, carrying sheave wheels at the top and allowing the necessary counterweight to slide inside the pipe. The frame is mounted on a trunnion and in its lower position, as shown by dotted lines, is rolled over to insert the tracing and blueprint paper, and is then raised to any desired position so as to secure the best light for printing. It can be swung at any angle and seems to be an ingenious way out of a difficult situation, at the same time taking up very little space in the room below.

The whole thing is balanced very nicely so that a sudden application of the foot to the lever shown at the bottom of one of the pipes throws the frame up or down as desired.

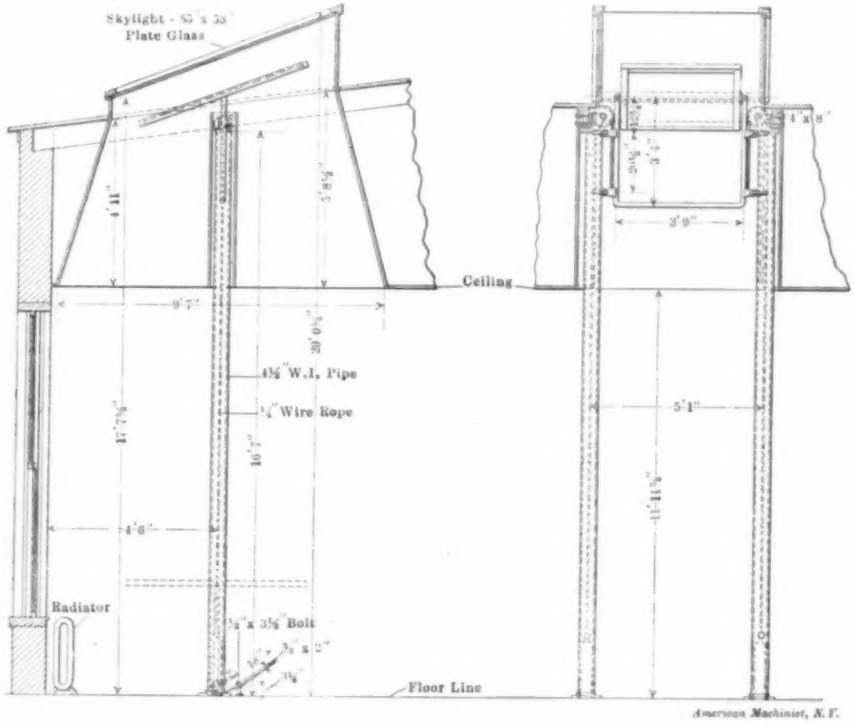


FIG. 2. ARRANGEMENT OF BLUEPRINTING FRAME AND APPARATUS

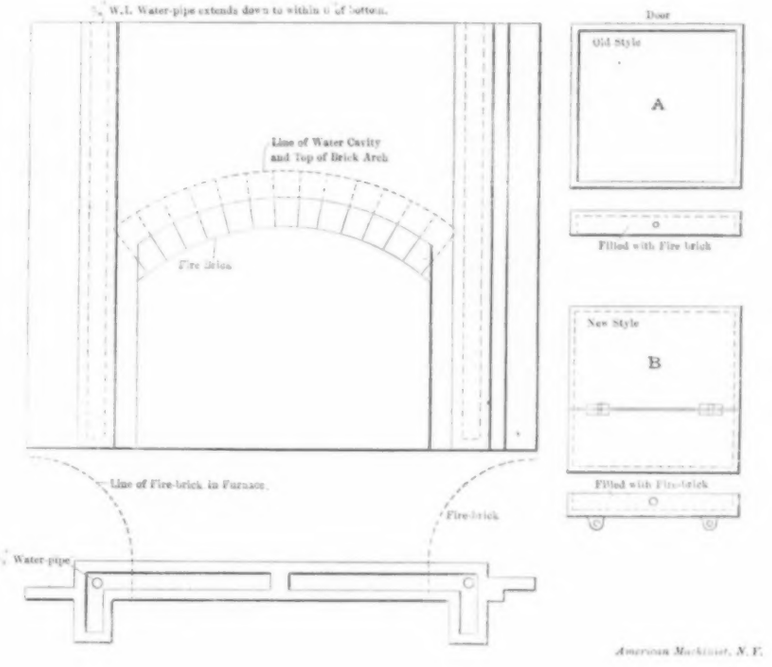


FIG. 3. SLIDING DOOR FRAME, WITH WATER BACK, FOR LARGE SCRAP HEATING FURNACE

Saving Money on Renewing Fire Doors

One of the little economies which indicates very clearly that things are being looked after much more than formerly is the fire door shown in Fig. 3. This is in connection with their large scrap-heating furnace which has the unusual water front and the door filled with firebrick as indicated.

These doors burn out quite rapidly, and it was observed that practically all of the damage occurred at the lower third of the door and that the upper portion was practically unharmed but had to be thrown away with the rest.

So a new door was designed, as shown at *B*, with the two parts hinged so that it is now an easy matter to remove the lower portion at a very much lower cost than before, while the upper part of the door very seldom needs attention.

A Tool-steel Testing Machine and Results

With a Turning Tool Cutting Speeds, Durability and Tool Angles Are Tested. Machine Also Tests Wear Resistance and Hardness

BY EDWARD G. HERBERT*

Most practical machinists have had some experience in testing tool steel. The test generally consists in putting a tool to work on the lathe, and observing how long it retains its edge, what weight of metal it will remove before it requires sharpening and what speed it will work at. The process is apparently simple, yet most of those who have had it to do will agree that it is by no means an easy one

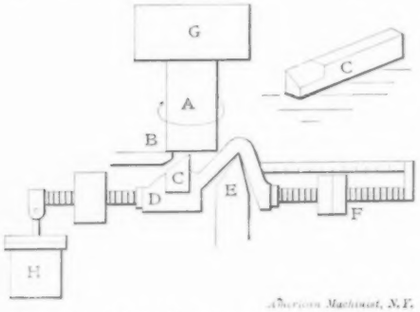


FIG. 1. DIAGRAM OF TESTING MACHINE

to carry out with anything approaching accuracy.

Assuming that the metal to be worked is beyond suspicion of containing "hard spots" it is soon found that the rigidity of the piece has a great influence on the durability of the tool; that it is very difficult under workshop conditions, to keep a series of tools working at exactly the same depth of cut long enough to wear them all out; that the diameter of the work and, therefore, the cutting speed is apt to vary; that all the tools may work satisfactorily on one speed of the lathe, and all fail quickly on the next higher speed. And, finally, there is the question "what constitutes a blunt tool?" The blunting of the edge usually commences at one spot, and gradually extends to the whole length of the cutting edge; at what stage is the tool to be considered blunt and the test at an end?

So real is the difficulty that steelmakers find it hard to induce prospective customers to make a trial of their steels; while many users adopt one out of the 50 brands of steel on the market without ever having made a competitive test of more than two or three. Perhaps the absence of any quick and reliable test of the cutting qualities of steel is felt most of all by the steelmaker who is experimenting with new ingredients or new methods of hardening, or who is confronted with a complaint from a customer as to the quality of his steel—a complaint which he believes to be groundless, but cannot refute.

These, and other, considerations led to the design of the machine which forms the subject of this article. The ideal aimed at was a machine which would make a quick and reliable test of the cutting properties of any tool steel, under conditions that could be accurately adjusted, and kept absolutely uniform. A machine which would enable the cutting quality of

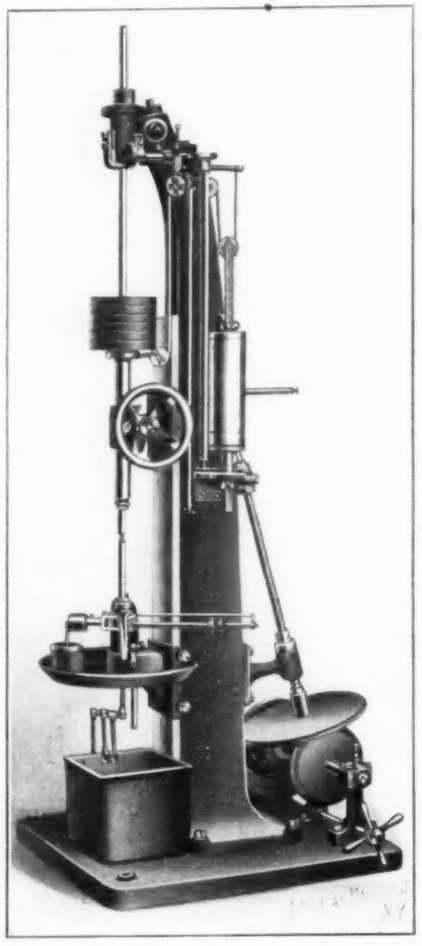


FIG. 2. THE TOOL-STEEL TESTING MACHINE

a steel to be expressed by a single number, just as its tensile strength can be expressed in pounds per square inch. How far this ideal has been obtained must be judged from the following description of the machine and the results obtained from it.

Principle and Construction of the Machine

The principle of the tool-steel testing machine will be readily understood with the aid of the diagram, Fig. 1, in which *A* represents a tube, usually of steel, ¾ inch in diameter and ⅝-inch bore, revolving about a vertical axis in the direction indicated by the arrow, with its lower end resting on a fixed abutment *B* of hardened steel. The steel to be tested is made into a tool *C* which, as shown in the perspective view, is ground something like a left-hand side tool. The tool is held in a vise *D* which is balanced on knife edges represented diagrammatically by *E*. Attached to the vise is a steelyard *F* with a movable poise and scale. A dash pot *H* steadies the vise and tool, and prevents vibration. By a suitable adjustment of the poise on the steelyard, the tool can be caused to press upward against the end of the tube with any desired force. The tube is held down in the abutment *B* by the weight *G*, and the downward pressure is always in excess of the upward pressure of the tool, so that the tube, as it is turned away by the tool, is constantly fed downward and kept in contact with the abutment *B*. The point at which cutting takes place is, therefore, stationary. The tool continues to turn away the tube as long as it remains sharp enough to penetrate the metal, but eventually it attains that definite degree of bluntness at which its upward pressure against the tube is no longer sufficient to cause it to cut, and it then slips over the surface of the tube without further cutting action.

Referring now to the illustration of the machine, Fig. 2, it will be seen that the

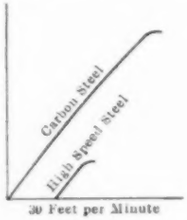


FIG. 3. HIGH-SPEED AND CARBON STEELS AT SLOW SPEED

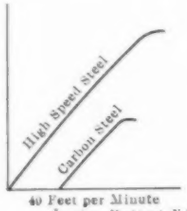


FIG. 4. HIGH-SPEED AND CARBON STEELS AT HIGHER SPEED

tube is driven by a vertical spindle, which receives its motion through cone and friction disk gearing, capable of giving it a wide and continuous range of speeds. A drum covered with squared paper is driven from the spindle through worm and spur gearing, so as to make one revolution to 24,000 revolutions of the spindle. A pencil mounted on a sliding bar is connected to the spindle by a fine chain, so that vertical movements of the spindle are communicated to the pencil. The combined movements of the drum

*Director, Edward G. Herbert, Ltd., Manchester, England.

and pencil result in drawing a line on the paper, whose slope measures the rate at which the spindle moves downward, that is, the rate (in inches per 1000 revolutions) at which the tube is being turned away by the tool. When cutting ceases, the line becomes horizontal, since the drum continues to revolve, while the pencil remains stationary.

Now suppose the hardness of the tube and the speed at which it is driven, the rake and clearance angles of the tool and the force with which it is pressed against the tube, are all exactly known and constant; then the tube will be cut away at a certain definite rate which will be shown by the slope of the line drawn, but any variation in any one of the conditions will be shown by a variation in the slope of the line, which thus acts as an absolute check on the uniformity of the conditions.

There is one remaining condition besides those enumerated above, which is variable and which affects the rate of cutting; namely, the sharpness of the tool. This varies at a rate which depends (other things being equal) simply on the quality and temper of the steel of which it is made. Owing to the vise being balanced on knife edges, loss of sharpness can only take place up to a certain definite degree of bluntness, measured by the slipping of the tool. Therefore, the number of revolutions made by the tube before this slipping takes place is an exact measure of the quality of the tool steel.

In practice one side of the tool is ground perfectly flat, and is held against the fixed jaw of the vise. A pointer is attached to the vise, and by setting this to an index mark, the fixed jaw is brought to a vertical position, with the tool in contact with the tube. Set in this position, the tool has no rake. It is ground with a clearance angle of 20 degrees. This form of tool is adopted partly for the sake of simplicity. It involves the grounding of only one angle, and is easily set. It is not the most efficient form for cutting, but this is in itself an advantage, as an inefficient tool is worn out sooner than an efficient one, and the object is not to cut away the maximum amount of stock, but to wear the tool out in a reasonably short time under standard conditions, measuring its quality by its resistance to wear. The angles of the tool can, however, be varied if it is desirable. If the test tube is of soft steel the tool must have some rake, in order to make a clean cut without burring the tube and so increasing the width of contact of the cutting edge. Rake can be provided for with the same type of tool, by the use of vise jaws tapered at the desired angle.

It might at first sight appear that a good tool would turn away a great length of tube before becoming blunt. That this is not so in practice is due partly to the shape and position of the tool, and partly to the composition of the test tube. The latter is made of a special steel containing 0.6 per cent. carbon, 0.83 per cent. manganese, and 0.21 per cent. silicon. This steel has great wearing properties, and it is subjected to a special heat treatment which gives it considerable hardness and great uniformity. A good tool will be blunted by turning away a few inches of this steel, the feed being usually about 0.001 inch per revolution.

Results Obtained from the Machine

The first tool-steel tests were arranged with a view to proving the reliability of the machine by comparing the cutting qualities of a piece of ordinary carbon hard tool steel, and a very good high-speed steel. A tool was made of each, carefully ground with 0 degree rake and 20 degrees clearance, and both were tested under the same conditions, with 15 pounds pressure and a cutting speed of 30 feet per minute, under a copious flow of water.

The results are shown in Fig. 3, in which diagram vertical distances represent inches of tube turned away and horizontal distances represent revolutions made by the tube. The short, horizontal portion of the curve indicates that the tool had become too blunt to cut under 15 pounds pressure, and it will be noticed that as this slipping of the tool occurred with great abruptness, and with very little previous loss of efficiency, the line is only slightly curved.

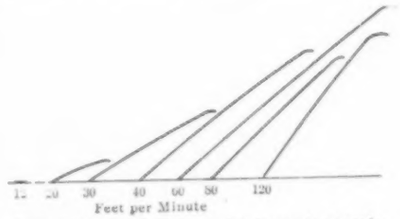


FIG. 5. Tests of Carbon Steel at Increasing Speeds.

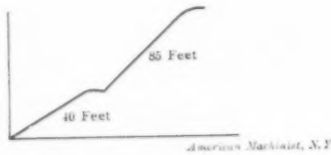


FIG. 6. EFFECT OF INCREASING SPEED ON A BLUNT TOOL

Both tools cut at the same rate, as was anticipated, but the unexpected feature of the tests was that the carbon steel lasted four times as long as the high-speed steel. As this result seemed obviously wrong, the tests were repeated with the same high-speed tool rehardened, and with other brands of high-speed steel, but always with the same result; the cast steel did several times as much work as the high-speed steel. The cutting speed was then increased from 30 to 40 feet per minute, with the result shown in Fig. 4. The high-speed steel now did twice as much work as the cast steel.

A number of tools were next made from various steels, and tests were made with each at cutting speeds ranging from 12 to 120 feet per minute, all the other conditions remaining constant. One such series of tests is shown in Fig. 5.

Several points will be noticed about these results. The tool would not cut at all at 12 feet per minute, under the pressure of 15 pounds, and this was the same with all the tools though all were as sharp as it was possible to make them. As the speed was progressively increased the amount of metal removed per revolution increased (as shown by the increasing steepness of the curves) and there was also an increase in the amount of metal removed before the tool became so blunt as to slip. It was also noticed that at the higher speeds the tools continued cutting until they were in a very bad condition, with quite a deep groove worn in the edge, while at the low speeds they slipped as soon as the edge was very slightly worn. These results which were common to all the tools, were quite unexpected and decidedly puzzling. No adequate explanation is offered, but the phenomena have since been confirmed in many ways in the machine shop, and their recognition has been of some practical value.

They can easily be verified as follows: Place a cylindrical article in a back geared lathe, and try to turn it with a hand tool while running at the slowest speed. It will be found impossible to make the tool "bite" without using considerable pressure. Put the lathe on a high speed, and the same tool will cut freely with the lightest pressure. Put the lathe on a moderately low speed and turn until the tool becomes too blunt to cut, which will occur very soon. Now put the lathe on the high speed, and the same blunt tool will cut quite freely. This was illustrated on the testing machine, Fig. 6, by running the tube at 40 feet until the tool was blunt enough to slip; increasing the speed to 85 per minute the same blunt tool at once began cutting faster than when it was sharp and cutting at the lower speed. It is necessary to bear these results in mind in considering the results which follow.

When tests of a number of tools had been made at various speeds, the results were plotted out in the form of a single diagram, Fig. 7, in which vertical distances represent the number of revolutions made by the tube before the tool slipped and horizontal distances represent cutting speeds in feet per minute. Curve *A* is from an ordinary cast steel; *B*, *C* and *D* are from three brands of high-speed steel.

Particular attention is drawn to the behavior of the different steels at low speeds. Starting at 12 feet per minute, at which speed none of the tools would cut as explained the "speed curve" of the cast steel rises at once, and attains its maximum hight at 55 feet. All the high-speed steels show a very gradual slope, with a durability several times less than that of the carbon steel up to a speed of 30 feet or more, and then rise very suddenly high above the cast steel.

Bearing of These Results on File Performance

The information conveyed by the speed curves was at once seen to have an important bearing on a subject in which I am especially interested—the testing of files.

The average cutting speed of a file in the file-testing machine is 25 feet per minute, which is also an ordinary speed for hand filing. The pressure of the file on the steel test bar is 30 pounds, which pressure is distributed among a considerable number of file teeth, and cannot amount to more than 15 pounds per 1/16 inch of cutting edge, the pressure used in the steel tests. It is, therefore, evident that the action of the tool used in the steel tests, when working at 25 feet per minute, corresponds very closely with the action of a single-file tooth under ordinary filing conditions. And the speed curves show that at this speed and under these conditions a piece of ordinary carbon hard tool steel was several times as durable as the best high-speed steel.

Now files are not made of high-speed

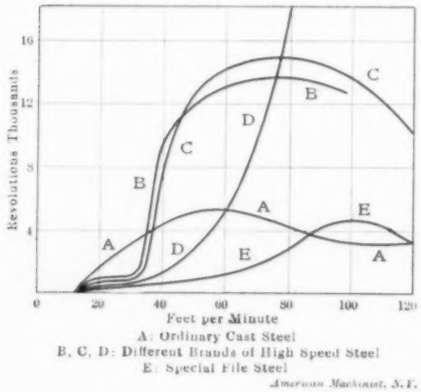


FIG. 7. SPEED CURVES OF VARIOUS STEELS

steel, but they are sometimes made of special alloy steels. It has been a constant charge against the file-testing machine that it often shows very poor results from these special files, and much better results from files of quite a common quality of carbon steel. The question, therefore, suggested itself whether some of the alloy steels might not give speed curves having some resemblance to those of the high-speed steels.

In order to settle this question a tool was made from an actual file of a very expensive make, said to be of a special alloy steel, but which gives particularly poor results on the file-testing machine. The resulting speed curve is shown at *E*, Fig. 7, from which it appears that at a cutting speed of 25 feet the durability of this steel is lower than that of any steel that has yet been tested. The speed curve has a general resemblance to that of the high-speed steels, but the peak is very low, and the curve does not rise above that of the cast steel until a speed of 85 feet per minute is exceeded. As to how far the results have a bearing on the use of high-speed steel in reamers, milling cutters for light finishing cuts, and other tools that are sold under similar conditions, it is too soon to say anything definite. It seems probable that when the meaning of the speed curves is fully understood, they will give most useful guidance in the choice of steel for particular working conditions.

It has already been explained that at any given speed all the tools cease cutting when they have reached the same condition of bluntness, but that at the higher speeds the tools continue cutting until they are in a much worse condition. It follows that the speed curves give a correct comparison of the durability of the steels at any given speed, but that they do not show the relative durability of the same steel at different speeds.

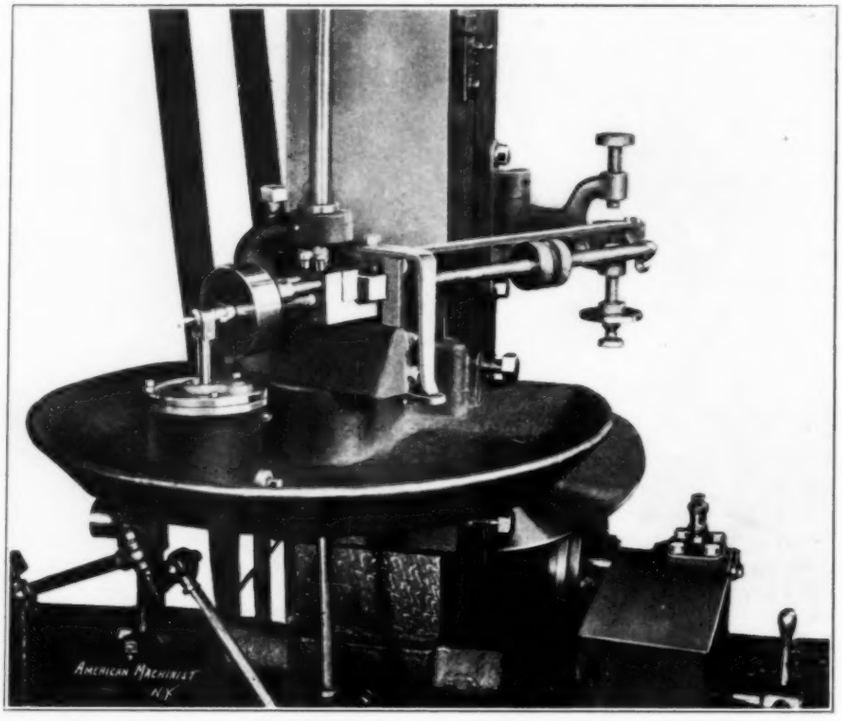


FIG. 8. MICROMETER ATTACHMENT FOR MEASURING WEAR OF CUTTING TOOLS

Micrometer Attachment for Measuring Wear of Tool

In order to eliminate this disturbing factor the testing machine was fitted with a micrometer attachment for measuring the amount of wear of the tool while cutting is in progress. It is evident that as the cutting edge wears away, the tool must rise in order to continue cutting at the same rate, and that as the tool rises the steelyard will fall through a proportionate but much greater distance. The micrometer, Fig. 8, is attached to the column and provided with two screws capable of bearing on the end of the steelyard. The upper screw can be used to depress the steelyard and force the tool into the tube to any desired depth of cut. The lower screw acts as a stop to limit the movement of the steelyard due to the wear of the cutting edge. It is provided with a dial, the graduations on which correspond to vertical movements of the tool in thousandths of an inch. The whole micrometer is insulated and electrically connected so that a bell rings when contact is made between either screw and the steelyard.

The micrometer is used as follows: The depth of the cut is decided beforehand, and a line is ruled on the diagram sheet, sloping at an angle corresponding with the desired number of inches per 1000 revolutions. The pencil is set on this line and the weight on the steelyard is adjusted until the pencil is seen to be traveling along the line previously ruled. (The correct position of the weight is generally known beforehand for each speed, and the standard feed of 0.0012 inch per revolution.) As soon as the cut is set the lower micrometer screw is adjusted for the required number of thousandths of wear. As the test proceeds the cutting edge wears and the steelyard falls until, when the predetermined amount of wear has taken place, the steelyard makes contact with the stop screw, the bell rings, and the test is stopped. The number of inches turned away, measuring the durability of the tool is read directly from the diagram. Under this system both the depth of cut and the wear of the tool are the same at all speeds.

A set of equal-wear speed curves is shown in Fig. 9; where *A* is from a carbon steel, and *B*, *B'*, *C* from high-speed steels. In this diagram vertical distances give the durability of the tool at each

speed (in inches of tube turned away). The marked superiority of the carbon steel at low speeds (with a light cut) is again clearly shown.

Low Speeds no Less Destructive than High Ones

Perhaps the most striking and important fact brought out by these curves is this: Very low speeds are no less destructive of the edge of a cutting tool than very high speeds, and this applies to every kind of steel that has been tested. It is a familiar fact that high-speed steel does not keep its edge well under light finishing cuts, but that it does keep its edge under heavier cuts. The speed curves show that a good high-speed steel preserves its edge under a very light cut better than a carbon steel, *if the speed is sufficiently high.* This fact, that the durability of a tool can be improved by increasing the speed, may be familiar to some who have experience of cutting tools. To me it came as a revelation, and it has been applied with marked success to the practical operations of the workshop. The peak of the speed curve, where the durability of the tool is at its maximum, covers a narrow range of speeds, and the durability falls rapidly as the

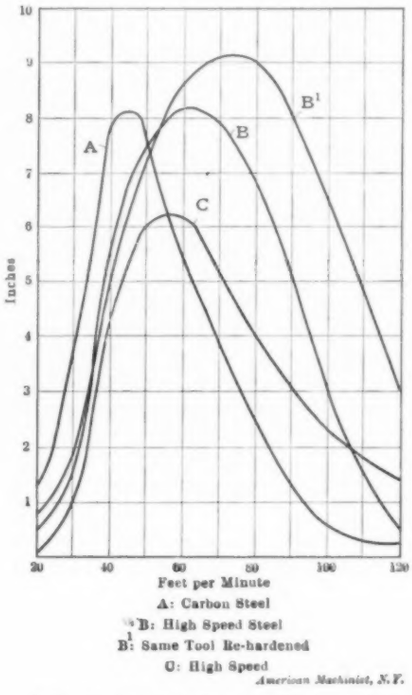


FIG. 9. EQUAL WEAR SPEED CURVES

speed is decreased or increased beyond these narrow limits. The speed curves give a true picture of the durability of steels at various cutting speeds, but they fail to give a correct impression of the rates of removing metal, which are of primary importance in practical work.

"Duty" of a Tool

If we multiply the durability of the tool at any speed, by that speed, we obtain a quantity, which may be termed the "duty," and which is proportional to the durability of the tool, and to the rate at which metal is being removed. It is reasonable to suppose that when this quantity attains a maximum the ideal working conditions have been arrived at. Fig. 10 shows the duty curves derived by calculation from the speed curves in Fig. 9, and gives a correct impression of the relative superiority of the high-speed steels for the rapid removal of metal. The curves *B B'* in Figs. 9 and 10 are both from the same high-speed steel. Tool *B* was hardened in the open fire and air blast; tool *B'* was hardened in the Brayshaw furnace and quenched in red-hot salt. It is interesting to note that the result of more correct hardening is to move the speed and duty curves to the right, giving the tool much greater durability at the higher

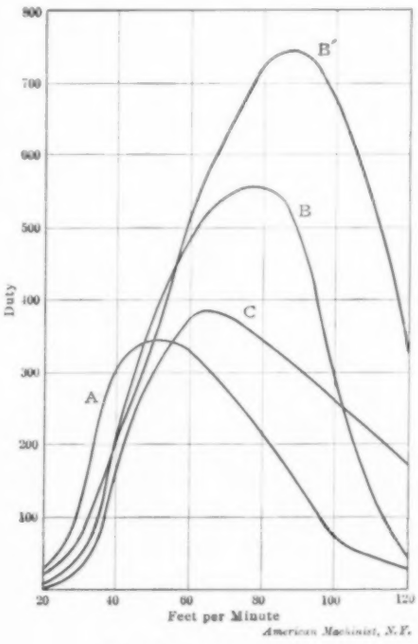


FIG. 10. DUTY CURVES

A—Carbon steel. Others—High-speed steel

speeds and slightly decreasing its durability at some of the lower speeds. There is no doubt that the speed curves will give very valuable information as to the influence of the various ingredients in the steel and of various methods of treating it, on its working properties. The object aimed at in all modern improvements in the making and hardening of steel, has been to move the speed curve to the right. It has not always been realized that a movement of the curve to the right usually involves a loss of durability at the lower speeds. In many cases this is not important but when the steel is to be made up into taps, reamers and especially files, the important classes of tools which must necessarily be used at low speeds and under comparatively light cuts, it would obviously be an advantage to move the speed curve to the left, to increase the durability of the steel at the low speeds while disregarding the high ones. Probably improvements in this direction will follow shortly on the introduction of the machine which enables the speed curves to be accurately drawn and compared.

The tendency of the speed and duty curves to move to the right is well shown in Fig. 11, in which are shown duty curves taken from *A*, a carbon steel, *B'* a good high-speed steel, and *D* one of the new steels which have been the subject of so

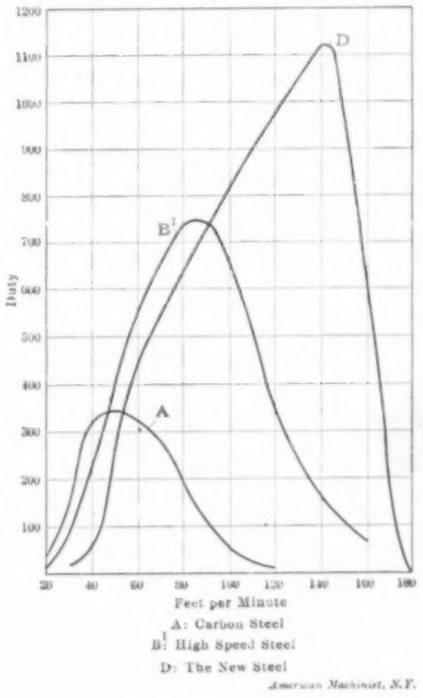


FIG. 11. DUTY CURVES

much recent discussion. It will be seen that whereas the high-speed steel gave its maximum duty at a speed of 90 feet a minute, it was necessary to increase the cutting speed to 140 feet in order to obtain the maximum duty of the new steel. It is also important to notice that at the speeds which gave the best results with high-speed steel, the new steel was distinctly less durable, while at speeds below 45 feet, the highest durability was shown by the carbon steel and the lowest by the new steel.

This diagram explains the great diversity of opinion as to the merits of the new steel, which has manifested itself among those who have tried it. Some say it is the best thing ever produced, others that it has been greatly overrated.

Most practical men would agree that the only correct way to compare the quality of different steels is to set them all to work under the same conditions, and note which stands up longest. It is clear from Fig. 11 that the result of such a test will depend on the particular conditions that have been adopted in making it. Unless the conditions are such as to tax the best steel to its utmost capacity, the test will give a very false impression of the

relative qualities of the steels, and it is quite possible for the order of merit to be exactly reversed by altering the conditions. Even if the choice of conditions is such as to lead to the selection of the best steel, it does not follow that the result of the test will be confirmed in practice; indeed this certainly will not be the case unless working conditions are so adjusted as to take full advantage of the properties of the steel.

The tests in Figs. 9, 10 and 11 were all made with tools taking a chip 1/16 inch wide and 0.0012 thick, on a steel of an exceedingly refractory character (tensile strength 58 tons). The cuts were much lighter and the speeds much higher than those which would be practicable or desirable under workshop conditions. The question naturally arises, whether it is possible to pass, by calculation, from the abnormal conditions of the testing machine to those which obtain in ordinary practice.

Wear and Durability of a Tool

A good deal has been written on the subject of the relation of cut and speed with reference to their influence on the wear of the cutting tool. It is generally recognized that the two are interdependent, and to some extent convertible, although no generally applicable law governing their relation has yet been formulated.

It appears that the tool-steel-testing machine is an almost ideal instrument for determining this relation, and experiments are being undertaken with this end in view. In the meantime it is possible to anticipate with considerable confidence, the general form which this relation will assume. There seems little doubt that durability of a cutting tool is almost entirely dependent on the rate at which heat is generated in cutting, and this being so it follows that the durability of the tool will be the same for any combination of cut and speed which generates the same amount of heat in a given time.

Theoretical considerations lead to the conclusion that the rate at which heat is generated by a unit length of cutting edge, is proportional to the thickness of the chip multiplied by the cube of the cutting speed. If C_1, S_1 are the thickness of the chip and the cutting speed, respectively, at any point on the speed or duty curve, C_2, the thickness of the chip which is to be made in practical working, and S_2 the corresponding speed, then the relation will be expressed by the formula,

$$C_1 S_1^3 = C_2 S_2^3,$$

whence

$$S_2 = S_1 \sqrt[3]{\frac{C_1}{C_2}}$$

For example, the maximum durability of the high-speed tool B^1, Fig. 10, was obtained at a cutting speed of 75 feet per minute. The thickness of the chip was 0.0012 inch. What speed would give a maximum durability to this tool when taking a chip 1/16 inch thick? Here

$$S_2 = 75 \sqrt[3]{\frac{0.0012}{0.0625}} = 20$$

feet per minute.

The maximum duty of the same tool was obtained at 90 feet cutting speed, and by the same formula, the maximum duty with a chip 1/16 inch thick would require a cutting speed of 24 feet per minute. Several considerations must be taken into account in applying this formula:

(a) The quality of the steel operated on. Some idea of the character of the steel used for the test tubes will be gathered from the fact that no tool has yet been found capable of turning away more than 9 inches length of tube, ¾ inch diameter before reaching the limit of bluntness. Such steel is rarely met with in practice. It is exceedingly difficult to work under any conditions, and requires cutting speeds much lower than those which would be suitable for working ordinary steels. The cube formula has been applied with good results in calculating the speed for boring the test tubes, but other steels will have to be graded, according to hardness before the formula can be applied to them.

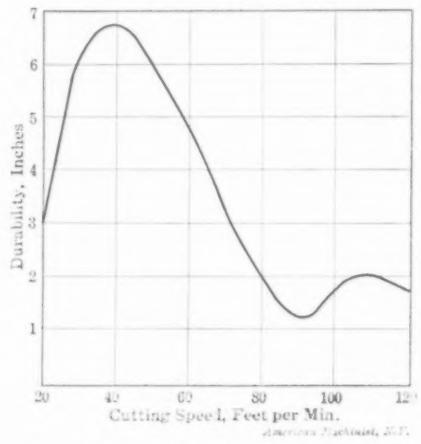


FIG. 12. SPEED CURVE OF CARBON STEEL

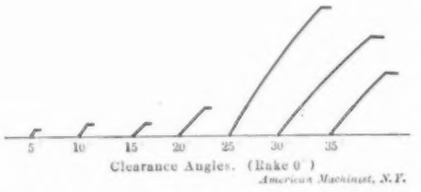


FIG. 13. CLEARANCE ANGLES AND DURABILITY

(b) An inefficient shape of cutting tool was deliberately chosen for making the tests. A tool with back slope or rake would generate less heat, and work at higher speeds.

(c) The ratio between the width and thickness of the chip has an important bearing on the cutting speed. In the tests described above, the width of the chip was 52 times its thickness. Such a ratio of width to thickness of chip may be found in wide-forming tools, milling cutters and turret-lathe turning tools. In such tools the cube law can probably be applied, taking account of the thickness of chip only, and ignoring its width. But in the case of roughing tools, the ratio of width to thickness of chip is much less, and in such cases theory, confirmed by the results of many experiments, leads to the conclusion that the cutting speed varies inversely as the cube root of the cross-sectional area of the cut. I hope to return to this subject in a future article. Further experiments will be required before it becomes possible to formulate definite relations between the conditions of the tests and the varying conditions of workshop practice. The speed curves may be relied on to show the relative qualities of steels and the relative speeds at which they work to best advantage, and this will always be their most valuable function.

One curious fact may be noted in connection with the heat theory of wear in cutting tools. In determining the speed curves of several of the steels it was found that at one particular speed the durability of the tool was less than its durability at a higher or a lower speed.

Although this was confirmed by repeated experiments, it was at first attributed to some unascertained variation in the conditions of the test, and was accordingly ignored in plotting the speed curves. From the results of a large number of experiments it now seems certain that the speed curve does really show a dip or dimple at one particular point, as will be seen in the speed curve of a carbon steel, Fig. 12. The appearance of this curve will be familiar to readers of the American Machinist. In a recent article (page 222) A. F. Shore gave a description of his experiments on the strength of tempered steel. Mr. Shore found that when carbon steel was made "dead hard" and let down to a temperature corresponding to a brown temper it was decidedly weaker than when let down to the yellow temper above, or to the blue temper below, and these results when plotted out, gave a curve having a striking resemblance to that in Fig. 12. It is difficult to resist the conclusion that the phenomenon is the same, though the means by which it was exhibited were totally different in character. Assuming this to be the case, it seems possible to advance an important step in theory of wear in cutting tools. The following theory is put forward, subject to confirmation by experiments which will be undertaken on the tool-steel-testing machine.

The maximum durability of a (carbon steel) cutting tool is attained when the working conditions (including hardness of material operated upon, shape of tool, feed, cut, and speed) are such as to raise the temperature of the extreme edge to the temperature at which the tool was

tempered. If the working temperature is increased (owing to increase of speed, etc.), beyond the temperature at which the tool was tempered, the durability will, in general, fall until the extreme cutting edge is "tempered to a brown." A further increase of speed or cut, sufficient to draw the temper of the extreme cutting edge to a blue, will increase the durability of the tool, because steel at a blue temper is stronger than at a brown temper and therefore better able to resist wear. If the tool was originally tempered too hard, i.e., let down at a temperature too low to give the steel its maximum strength, the maximum durability of the tool will be obtained when the working conditions are such as to draw the temper of the cutting edge to the temper corresponding to the maximum strength of the steel, provided, of course, that the excessive hardness of the tool does not cause breakage.

The dimple in the carbon-steel speed curve occurs at a point where the steel is considerably overworked, i.e., heated beyond the temperature of maximum durability, and it is, therefore, of no great practical importance. There is reason to believe that the curves of high-speed steels also have a dimple, and that it occurs at a point well within the range of useful working conditions. Further investigation is necessary before any very definite statement can be made on this point.

Rake, Clearance and Slope in Relation to Efficiency and Durability

Besides its primary function of measuring the quality of tool steels, the tool-steel-testing machine opens a wide field of inquiry into all phenomena connected with the action of cutting tools. In particular it is capable of yielding valuable information relative to the problems of file-tooth action. It is evident that by a suitable adjustment of pressure and cutting speed, the tool may be made to imitate closely the action of a single-file tooth, and by varying the angles of clearance, rake and slope, with which it is presented to the work, it is possible to obtain autographic records, showing the effect of a given alteration of any one of these angles, not only on the efficiency or rate at which metal is filed away, but also on the durability or lasting power of the cutting edge, and on the total output of work which can be obtained with any form of cutting edge before it becomes too blunt to cut. Nothing approaching a complete investigation of these problems has yet been undertaken, but the few experiments that have been made will serve to show the character of the information obtainable.

A series of tests was made to ascertain the effect of different degrees of clearance on the efficiency and durability. The same tool was used throughout, each test being made with a perfectly sharp edge, and continued until the tool slipped. The tool had 0 degree rake and the cutting edge was radial to the tube and, therefore, at right angles to the direction of cutting (90 degrees slope). The clearance angle was varied by steps of 5 degrees from 5 degrees in the first test to 35 degrees in the last. The results are shown in Fig. 13. From a general view of these curves it appears that the clearance angle has very little influence on efficiency, the slope being nearly the same in all cases, though the test with 25 degrees clearance shows a rather higher efficiency. The most remarkable feature of the results is, however, the great difference in the durability of the tool and in the output of work. The tool

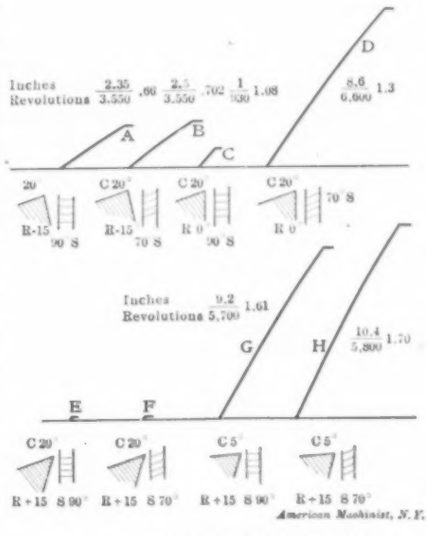


FIG. 14. ANGLES OF RAKE AND SLOPE

FIG. 15. SUGGESTED TYPE OF TOOTH FOR FILES, SAWS AND CUTTERS

with 5 degrees clearance slipped after turning away 1/20 inch of tube. The same tool with the clearance increased to 25 degrees removed 3.7 inches of tube, or 74 times as much as before.. With 30 and 35 degrees clearance there was a decrease in the output of work. This was due to the edge of the tool breaking away. Each curve is the mean of several tests, some of which were very short owing to the chipping of the edge. Evidently a clearance angle of more than 25 degrees gave too weak a tooth. The tests were made with a pressure of 25 pounds. The results give a striking confirmation of the conclusion that had already been arrived at, as a result of a large number of file tests, that the life of a file and the total output of work obtainable from it, depend far more on the shape of the file teeth than on the quality of the file steel, important as this undoubtedly is.

A further series of tests was made to ascertain the influence of rake and slope on the efficiency and durability of cutting tools in general, and file teeth in particular. The term "slope" is here used to designate the angle at which the chief or "up" cut lies across the face of the file. The rake angles experimented with were three: A negative rake of 15 degrees, corresponding to the backward leaning front face of almost all file teeth; a zero rake, as usually found in the teeth of hack-saw blades and milling cutters, and a positive rake of 15 degrees. Every one of these rake angles was tested at two slope angles, a 90-degree slope corresponding to the cut of a brass file or a straight-tooth milling cutter, and a 70-degree slope, corresponding to the cut of an ordinary file for general work, or a spiral milling cutter. The same tool was used throughout with a pressure of 25 pounds. The clearance angle was 20 degrees in all, except two of the tests. The results are shown in Fig. 14. Beside each curve is given the number of inches of tube turned away, the number of revolutions made by the tube, and the average efficiency in inches per 1000 revolutions. Below each curve is a profile of the tool, and a representation of a file showing the slope of the up cut. Curves *A* and *B* correspond to the tooth of a brass file and an ordinary file, respectively, the latter showing a rather higher efficiency and durability. The sloping cut *B* would, no doubt, show to greater advantage on a softer material than was used in the test.

Curves *C* and *D* correspond to a straight tooth, and a spiral-tooth milling cutter. Both show an efficiency much higher than in the previous tests, and the advantage of the sloping or spiral cut in increasing both the efficiency and durability of the cutting edge is strikingly shown. In tests *E* and *F* the edge broke away directly as the cut was started. This form of tooth is obviously too weak. In order to strengthen the cutting edge, these tests were repeated with the same rake + 15 degrees, but with the clearance angle reduced from 25 to 5 degrees (curves *G* and *H*). In these tests both the efficiency and the durability of the cutting edge were considerably higher than in any of the previous tests, a result which seems to confirm an opinion, long held by me, that all cutting tools, whether files, cutters or hack saws should be made with positive rake. To obtain sufficient strength and at the same time leave room for the cuttings, it would be advisable to adopt the form of tooth shown in Fig. 15. Milling cutters with this form of tooth have been tried and have given good results. Their manufacture presents no difficulty and probably the same might be said of hack saws.

In the case of the file tooth, the front face is formed by contact with the chisel, and it can obviously be given positive rake by suitably coördinating the direction of the blow and the angle at which the chisel is ground. The back face of the working part of the file tooth never comes in contact with the chisel. It is formed by a burring or raising up of the metal, and the amount of the clearance angle depends on the extent to which this raising action

takes place. Files made from a hard quality of steel often give very poor results, because the steel, having little ductility, does not rise readily under the influence of the blow. The result is a small clearance angle and the effect of this on the output of the work was shown in Fig. 13. But the tests shown in Fig. 14, curves *G* and *H*, show that if the tooth has positive, instead of negative, or zero rake, a high efficiency and a large output of work are obtained with a very small clearance angle. It would seem then, that in cutting a file of high-carbon steel, the form of tooth would be produced which has the greatest efficiency, durability and strength, while the quality of the steel would tell to the utmost advantage, instead of being a positive disadvantage, as it is when the file is cut in the usual manner with negative rake.

Enough has been said to indicate the possibilities of the tool-steel-testing machine in elucidating the problems connected with cutting tools. The investigation of these problems to be complete, must take account of the power absorbed in cutting. This can be provided for by mounting the vise and parts connected therewith on anti-friction bearings so that they are free to turn about the axis of the test tube. This turning action is made sluggish by a dashpot and counterbalanced by a spring balance, by means of which the torque exerted by the test tube on the tool, can be measured and the power calculated. The machine shown in the illustration is not fitted with this arrangement.

Determining the Effects of Lubricants

A subsidiary, but not unimportant, use of the tool-steel-testing machine is that of measuring the efficacy of lubricants for

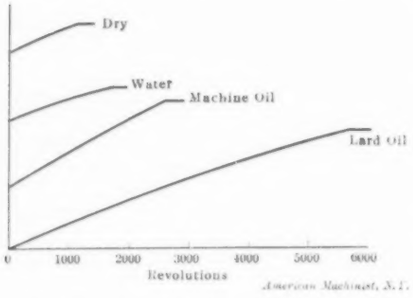


FIG. 16. CUTTING TOOLS WITH VARIOUS LUBRICANTS

preventing the wear of cutting tools. Fig. 16 shows tests of the same tool cutting dry and lubricated with water, machine oil and lard oil, respectively. The tests were not made at a speed sufficiently high to generate much heat.

Determining Wear Resistance

Another application of the testing machine is to the measurement of the wear-resisting qualities of metals, or of different combinations of metals in frictional contact. In testing the combustion of, say, a steel and a bearing metal, the steel is made into a short tube (by drilling) and the bearing metal takes the form of a plate usually 1/16 inch thick, the latter being held in a vertical plane by a special vise, while the edge of the tube rests on and rubs across its edge so as to wear a groove. The amount of combined wear is read from the diagram in inches (depth of groove) per 100,000 revolutions. Some tests which were made with a tube of hardened-steel wearing plates of various soft steels may be of interest. In this case the tube showed no appreciable wear, and the diagrams showed simply the relative rates of wear of the various steel plates. A series of such diagrams is shown in Fig. 17, giving the relative rates of wear, and, conversely, the wear-resisting properties of soft machinery steel, steam rail, locomotive tire, and the steel used for the test tubes.

Further tests were made to ascertain

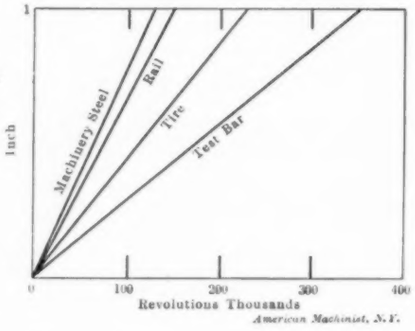


FIG. 17. WEARING TESTS OF SOFT STEELS

what is the relation between the rate of wear and the load. A plate of machinery steel was used in conjunction with a tube of hardened steel, and wearing tests were made at gradually increasing loads. Each test produced a diagram in the form of a straight line whose slope gave the rate at which the hard tube wore a groove in the soft steel. The various rates of wear, expressed in inches per 100,000 revolutions were used as ordinates in the diagram, Fig. 18, the corresponding loads being expressed in pounds per square inch of rubbing surface. The diagram shows that the rate of wear is directly proportional to the load, but that at a certain definite load (16,600 pounds per square inch) the wear suddenly begins to increase at a much greater ratio. There is evidently at this point a breaking down of the metal, which may be called the "wear yield point" corresponding to the yield point of materials under tension. How far the position of the wear yield point is influenced by the speed of rubbing, was not determined. It is evident that the determination of the wear yield point is of importance in connection with materials intended for structures subject to severe wear such as rails, tires and journals. Cases of unaccountably rapid wear such as occur sometimes in railway practice, may be due to a frictional load in excess of the yield point of the material.

All the wearing tests were made under a copious flow of water. No doubt the rate of wear under a given load, and possibly the position of the yield point, would be affected by the quality of the lubricant used. The testing machine affords a ready means of measuring and

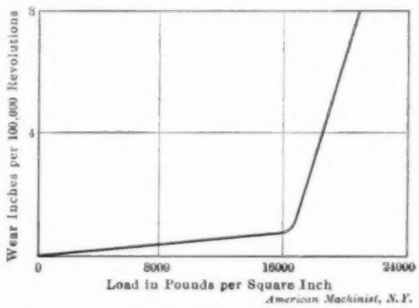


FIG. 18. RATE OF WEAR OF MACHINERY STEELS UNDER INCREASING LOAD

comparing the efficacy of different lubricants in preventing wear.

Testing the Hardness of Metals

The production of quantities of test bars for the file-testing machine and for the tool-steel-testing machine has called for a reliable test for hardness. Several methods have been tried, and eventually discarded in favor of the drill test, in which the hardness is judged by the rate of penetration of a weighted drill. The tool-steel-testing machine is specially well adapted for carrying out this test.

The drill test itself is by no means new, but it has generally been looked on with disfavor, because, as usually applied, it depends for its accuracy on absolute uniformity in the shape and sharpness of the drill. As this uniformity is difficult to secure, a modification of the test was introduced, in which uniform sharpness of the drill is no longer essential. The modification consists in the adoption of a standard rate of penetration in a standard reference bar. For instance, a penetration of 0.5 inch per thousand revolutions may be taken as a standard. Then the weight on the drill must be so adjusted that this standard rate of penetration is given on the reference bar. Tests on other bars can now be made with this standardized drill, and their hardness is given by the penetration per 1000 revolutions. From time to time a test is made on the reference bar, and if the rate of penetration is found to have altered, the drill is restandardized by adjustment of the weight. In practice a considerable number of tests can be made on ordinary materials without appreciable blunting of the drill. The sensitiveness of the test can be increased almost indefinitely by adopting a lower rate of penetration. A drill so lightly loaded as to be on the point of slipping, will plainly show differences of hardness

that cannot be detected by any other method known to the writer.

Every material has at least two kinds of hardness, and when the material is to be used for test bars or tubes, it is necessary to know something about both. To illustrate this point, imagine a mixture of two such substances as lead and emery. Is it hard or soft? Tested by any of the methods depending on indentation it would be pronounced very soft, but an attempt to work it with a cutting tool

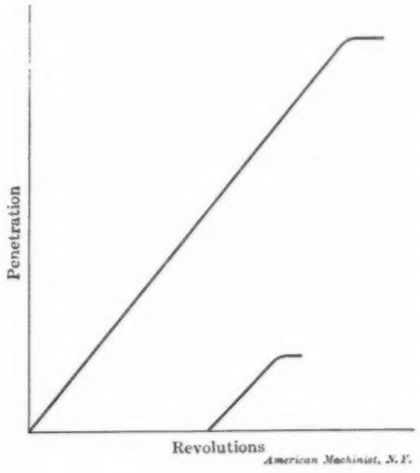


FIG. 19. DRILL TEST SHOWING PRIMARY AND SECONDARY HARDNESS

would lead to the conclusion that it was very hard. Now many varieties of steel and iron have characteristics similar to those of the lead and emery mixture. The microscope shows them to consist of a relatively soft material in which crystals of a much harder substance are embedded. The indentation tests and the drill test described above show only the primary hardness, that of the matrix. For many purposes it is desirable to measure also the secondary hardness depending on the particles embedded in it. This can be measured by means of the wearing test described above, or by a drill test made with a standardized drill and continued until the drill ceases to cut. In this case the primary hardness is shown by the rate at which the drill commences to cut. The secondary hardness is shown by the total number of revolutions or the total penetration from the commencement of the test until the drill ceases to cut. The primary hardness is measured by the action of the drill on the metal; the secondary by the action of the metal on the drill. In Fig. 19 are shown drill-test diagrams of two specimens of steel in which the primary hardness (measured by the slope of the line) was equal, although the secondary hardness (measured by the durability of the drill) was in the proportion of about 5 to 1.

The diagrams in Fig. 19 represent the mean of a number of observations. They are, of course, only relative, but such tests are of the greatest value in cases where a standard of both primary and secondary hardness has to be maintained. In comparing the secondary hardness of soft materials the temper of the drill may be drawn; otherwise the duration of the test is unduly long.

Some Close Approximations in the Circle

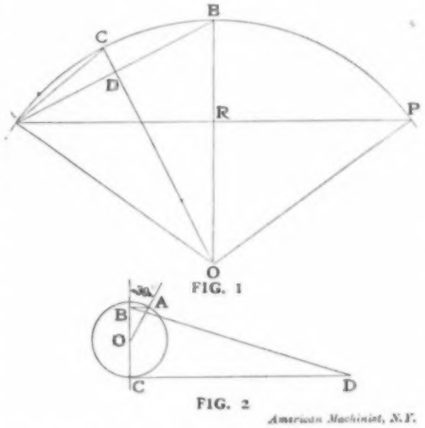
By W. L. Benitz

It is frequently necessary in some drafting constructions to determine the length of a portion of a circular arc which is to be used in some further construction in a proposed problem, as in some velocity diagrams and cam motions. The following method is both accurate and simple and, though old, having been invented by the Dutch mathematician Huyghens about 1680, I believe it is not generally known where it may be of most use:

If AB, Fig. 1, is the circular arc the length of which is desired, erect DC perpendicular to AB at its middle point. The length of the arc AB is then

$$\frac{8\,AC - AB}{3}.$$

This is the method for arcs of 60 degrees or less, but beyond 60 degrees the process



DIAGRAMS ILLUSTRATING SOME CLOSE APPROXIMATIONS IN THE CIRCLE

should be performed for half the arc and the result doubled.

The accuracy of the result is shown by the following calculation: In a circle having a radius of 10 inches let AB be an arc of 60 degrees. Then

$$AB = 10$$

inches, and

$$AC = 2 \times 10 \times \sin.\ 15\ degrees = 5.1764$$

inches. This gives the length of the arc

$$AB = \frac{8 \times 5.1764 - 10}{3} = 10.4704$$

inches. The actual length is one-sixth of the circumference of a circle 20 inches in diameter, or

$$\frac{\pi \times 20}{6} = 10.4720$$

inches. Thus the error is entirely negligible. Of course, this error is relatively less for arcs less than 60 degrees.

Since the area of a sector of a circle is one-half the product of the arc by the radius, we are able to find the area of a sector, and finally by subtracting from the sector the area of an isosceles triangle we arrive at the segment of a circle, which seems to be a stumbling block to a great many draftsmen. This will be done as follows: Suppose we measure in Fig. 1, $AO = 66$ inches, $AP = 106$ inches, $AB = 59\frac{3}{8}$ inches, $OR = 39$ inches, and $AC = 30\frac{1}{2}$ inches. We first find the length of half the arc, since it exceeds 60 degrees. Length arc

$$AB = \frac{8 \times 30.5 - 59.375}{3} = 61.54$$

inches. Arc ABP is twice this, or 123.08 inches. Area sector $OABP$ is

$$\tfrac{1}{2} \times 66 \times 123.08 = 4061.6$$

square inches. Area triangle OAP is

$$\tfrac{1}{2} \times 106 \times 39 = 2067$$

square inches. The difference of the last two results is the area of the segment $ABPA$, that is, 1994.6 square inches, and this result differs from the true value by less than one-half a square inch.

Howard C. Wiley's method of laying off the approximate length of the circumference of a circle, as given at page 448 is excellent, and as far as practical drafting is concerned might be termed exact, rather than approximate. I use a method somewhat different which, to my mind, is easier to construct, and the degree of approximation is very close. As shown in Fig. 2, OA is drawn at an angle of 30 degrees with the horizontal diameter ard AB is perpendicular to the same diameter; CD, which is three times the diameter, is laid off perpendicular to CO. The length of the circumference is given by DB. The error is about $\frac{1}{20000}$ of the circumference.

If anything at all is well established regarding reinforced concrete, says *Engineering News*, it is that the reinforcing steel must be kept clean from anything that would tend to destroy that bond between steel and concrete which is the safety of the joint material. Especially is the coating of the reinforcing rods with paint against possible corrosion a deplorable practice. It is not only unnecessary as a protective measure, but the substitution of two planes of poor bond, concrete to paint and paint to steel, for the one strong bond of concrete to steel is certainly weakening from a structural standpoint.

Experiments on Forces Acting on Twist Drills—II*

The Horsepower for a Given Drill and Feed Is Proportional to the Cutting Speed; for a Given Feed and Speed to the Drill Diameter

BY DEMPSTER SMITH AND R. POLIAKOFF

MEDIUM STEEL EXPERIMENTS—TORQUE

The trials (*f*) on medium hard steel are much more regular than those obtained with cast iron. The torque has been plotted as an ordinate on a base of feed per revolution in Fig. 11 and on a base of diameter of drill in Fig. 13. Like the cast iron it does not increase as fast as the feed.

A similar character to the cast-iron curve is observed in the variation of torque with diameter. This is generally confirmed by theoretical comparison with the lathe-tool experiments already referred to. These showed that the cutting pressure when operating on steel not only decreased with the feed but also with the depth of cut. A comparison between these stresses can easily be made after the manner of that for cast iron. The torque for the ¾-inch drill with a feed of 1/400 is 13 foot pounds, while with a 1/35 feed on the same drill the torque is 92.5 foot pounds, so that when the feed is increased 11.4 times the torque is only increased by 7.1 the amount. If the cutting pressure varied as the diameter of the drill then the torque would vary as the diameter squared. The torque for the 1/50 feed on 3-inch drill is 700 foot-pounds, whereas with the same feed on the ¾-inch drill it is 70 foot-pounds, or a ratio of 10 to 1, while the ratio of their squares is 16 to 1, thus showing that so far as the torque is concerned the most economical way to machine metal is to use a coarse feed and a large diameter of drill.

The strong full lines in Figs. 11 and 13 agree with the equations given in columns 2 and 3 of Table 5 respectively. Those in the latter column are the values deduced for each size of drill from the general expression

$$T = 2300\, d^{1.28 - \frac{1}{t^{0.1}} + 0.64} \qquad (31)$$

The fourth column of the Table 5 gives a linear law for each drill and the fifth the values deduced from the general expression given at the top of that column. These, however, while simple are rather approximate. For a rough comparison the form

$$T = 28\, d^2\, [1 + 100t] \qquad (32)$$

which is fairly near the mark for all feeds in common use, may be of help to some.

For ordinary practical use the index of *t*, which varies very little from 0.70 can

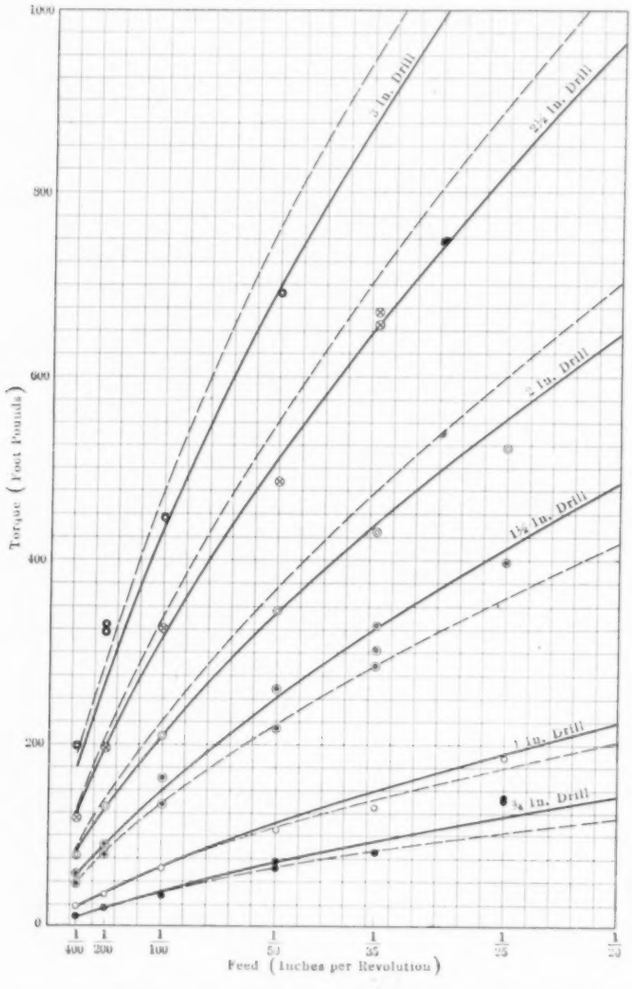


FIG. 11. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF TORQUE WITH FEED WHEN OPERATING ON MEDIUM STEEL

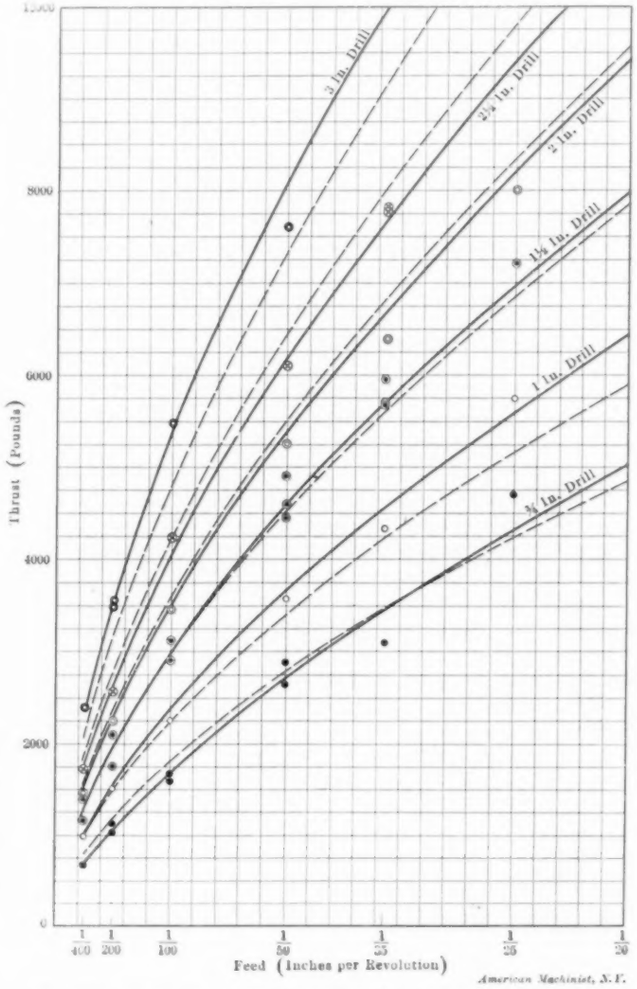


FIG. 12. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF THRUST WITH FEED WHEN OPERATING ON MEDIUM STEEL

*Continued from page 746.

be made constant and the coefficient modified to suit.

With this object in view the following fairly simple and approximate expression is afforded,

$$T = 1640\, d^{1.8}\, t^{0.70}. \qquad (33)$$

The values deduced from this equation are given in column 6 of Table 5, and to allow of a better comparison are shown by the thin broken lines on Figs. 11 and 13. With the exception of the coarsest feed these agree very well with the experimental results.

$$P = [18 + 22\, d]\ 1000\, t^{\frac{1}{20\,d} + 0.59} \qquad (34)$$

which is represented by the full lines on Fig. 14.

The values deduced from equation (34) for each diameter of drill are given in the third column of Table 5. At first glance these may appear to be very wide of the values given in column 2, but a small difference in the index of t (since t is always a small fractional value) makes a large alteration in the coefficient, so that the figures given are almost equal in value.

practical use, and for this reason it has not been offered.

With the object of further simplifying the above equation (34) the index of t has been taken as 0.6 (since it varies very little from that amount) throughout, and the coefficients given in column 2 modified to suit. These closely agree with the equation

$$P = 35{,}500\, d^{0.7}\, t^{0.6}. \qquad (36)$$

which correspond to the values for each diameter of drill given in column 6 of

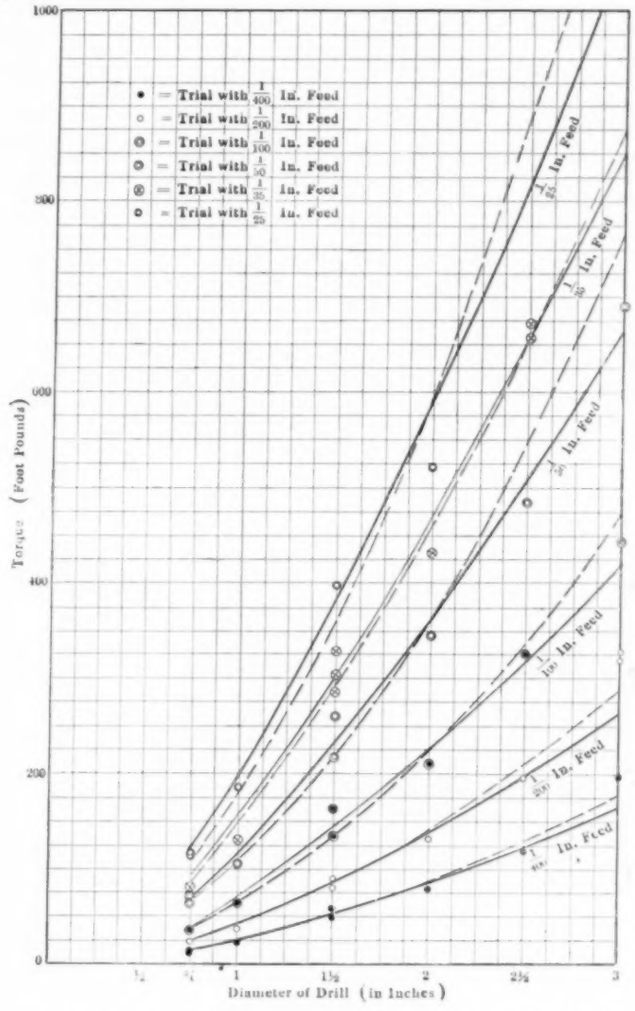

Torque (Foot Pounds)
Diameter of Drill (in Inches)
• = Trial with 1/400 In. Feed
○ = Trial with 1/200 In. Feed
◎ = Trial with 1/100 In. Feed
⊙ = Trial with 1/50 In. Feed
⊛ = Trial with 1/35 In. Feed
○ = Trial with 1/25 In. Feed
1/25 In. Feed
1/35 In. Feed
1/50 In. Feed
1/100 In. Feed
1/200 In. Feed
1/400 In. Feed

FIG. 13. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF TORQUE WITH DIAMETER WHEN OPERATING ON MEDIUM STEEL

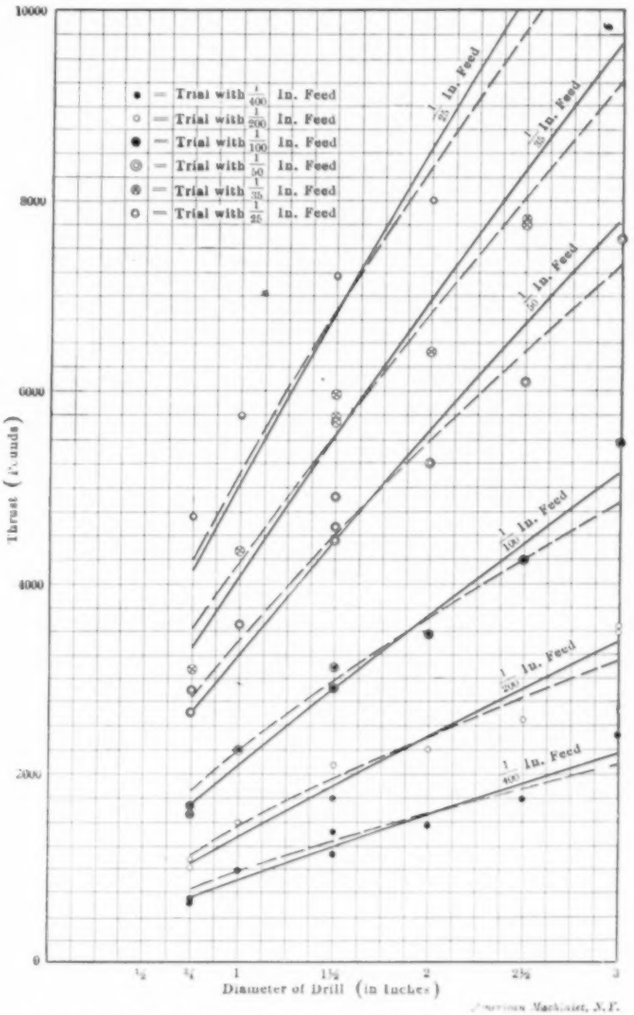

Thrust (Pounds)
Diameter of Drill (in Inches)
• = Trial with 1/400 In. Feed
○ = Trial with 1/200 In. Feed
◎ = Trial with 1/100 In. Feed
⊙ = Trial with 1/50 In. Feed
⊛ = Trial with 1/35 In. Feed
○ = Trial with 1/25 In. Feed
1/25 In. Feed
1/35 In. Feed
1/50 In. Feed
1/100 In. Feed
1/200 In. Feed
1/400 In. Feed

FIG. 14. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF THRUST WITH DIAMETER WHEN OPERATING ON MEDIUM STEEL

Medium Steel Experiments—Thrust

The thrust for medium steel has been plotted as an ordinate on the base of feed per revolution of the drill in Fig. 12 and on a base of diameter of drill in Fig. 14. It will be observed that these results are much more regular than those obtained on cast iron. The diagram clearly shows that the end thrust does not increase so fast as the feed for a given diameter of drill; neither does it increase as fast as the diameter for a given feed.

The strong full lines given on Fig. 12 correspond to the equations given in column 2 of Table 5. These have been combined to give the general formula,

The values given in columns 4 and 5 of Table 5 are approximately linear expressions, the former being the nearest obtained for each drill and the latter conforming to the general law given at the head of column 5.

A rougher but simpler rule,

$$P = 750\, d\, (1 + 150\, t) \qquad (35)$$

which is fairly correct for the range of feeds used in practice.

The results show that the index of t decreases with the increase of drill diameter, and while an equation could be given to fit these values it is apparent that it would be too cumbersome to be of much

Table 5, and shown by the dotted line on Figs. 12 and 14.

Up to the present no observations have been taken with blunt drills, but there was evidence during the trials to show that the thrust may increase 20 per cent. by the dulling of the chisel point alone, so that it would be useless to insist on the use of a closely accurate law for workshop practice.

Variation of Cutting Stress with Cutting Speed

The experiments discussed up to the present have been made at a constant speed of 10 revolutions per minute.

In trials (g) the speed when operating on soft cast iron (dry) varied from 7.5 to 126 revolutions per minute, with the object of determining the variation of thrust and torque due to speed with a given diameter of drill and feed. In neither case could it be said that there was any marked difference due to speed.

The experiments show that metal is most economically removed by increasing the feed or diameter of drill rather than the speed; since the power in the latter case is directly proportional to the speed. The friction horsepower of the machine is practically proportional to the speed, so that if the speed is doubled the power is also doubled. When the feed on the other hand is doubled the frictional horsepower remains about the same.

By increasing the number of lips to three or more, the torque and the thrust are increased for any given feed as the feed actually taken by each lip is $\frac{1}{n}$ of the whole feed; where n is the number of lips. No attempt has been made to determine the most durable speed for a given feed and diameter of drill. Tables 7 and 8 have been calculated from the above results for the speed and feed recommended by drill makers for ordinary workshop use.

There is no general agreement among the makers of high-speed twist drills as to what the cutting speed should be for ordinary workshop practice. Some decrease the speed with the increase of diameter of drill, some recommend the reverse, but the most makers advise a constant periphery speed throughout. The mean of these values is about 60 feet per minute with a feed per revolution of $\frac{d^{\frac{1}{2}}}{100}$ for mild steel. For cast iron it is usual to decrease the above speed 20 per cent. and increase the feed by a similar amount. Using these figures and the experimental force values given herein an estimate of the net horsepower required for drilling can be made.

1	2	3	4	5	6
		Torque in Foot Pounds. Equations corresponding to—			
Diam. of Drill in Inches.	Full Lines on Fig. 11.	General Law $T = \frac{1}{8d}{}^{1.28t} + 0.64$ Full Lines on Fig. 13.	Nearest Straight Line Law Not Drawn on Figures.	General Straight Line Law $T = 18d^2 + 100t$ $(27d^2 + 20)$ Not Drawn on Figures.	Approximate General Law $T = 1640d^{1.8}t^{0.7}$, Dotted Lines on Figs. 11 and 13.
$\frac{7}{8}$	$T = 1535t^{0.8}$	$T = 1625t^{0.807}$	$T = 7.5 + 3350t$	$T = 10.1 + 3310t$	$T = 977t^{0.7}$
1	$T = 2210t^{0.768}$	$T = 2250t^{0.765}$	$T = 17.5 + 4400t$	$T = 18 + 4700t$	$T = 1640t^{0.7}$
$1\frac{1}{2}$	$T = 4181t^{0.72}$	$T = 3945t^{0.723}$	$T = 40 + 9000t$	$T = 40.5 + 8070t$	$T = 3404t^{0.7}$
2	$T = 5250t^{0.7}$	$T = 5700t^{0.7025}$	$T = 75 + 12500t$	$T = 72 + 12800t$	$T = 5720t^{0.7}$
$2\frac{1}{2}$	$T = 7580t^{0.69}$	$T = 7580t^{0.69}$	$T = 112.5 + 19050t$	$T = 112.5 + 18800t$	$T = 8550t^{0.7}$
3	$T = 10000t^{0.68}$	$T = 9575t^{0.682}$	$T = 175 + 26250t$	$T = 162 + 26300t$	$T = 11840t^{0.7}$
		Thrust in Pounds. Equations corresponding to			
Diam. of Drill in Inches.	Full Mines on Fig. 12.	General Law $P = \frac{(18 + 22d)}{1000t^{.28t}} + 0.59$ Full Lines on Fig. 14.	Nearest Straight Line Law Not Drawn on Figures.	General Straight Line Law $P = 750d + 1000t$ $(75d + 50)$ Not Drawn on Figures.	Approximate General Law $P = 35500d^{0.7}t^{0.6}$, Dotted Lines on Figs. 12 and 14.
$\frac{7}{8}$	$P = 37450t^{0.681}$	$P = 34500t^{0.657}$	$P = 550 + 109000t$	$P = 560 + 106000t$	$P = 29020t^{0.6}$
1	$P = 40500t^{0.616}$	$P = 40000t^{0.64}$	$P = 750 + 131000t$	$P = 750 + 125000t$	$P = 35500t^{0.6}$
$1\frac{1}{2}$	$P = 52660t^{0.609}$	$P = 51000t^{0.623}$	$P = 1250 + 162000t$	$P = 1120 + 162000t$	$P = 47140t^{0.6}$
2	$P = 58100t^{0.608}$	$P = 62000t^{0.615}$	$P = 1500 + 181250t$	$P = 1500 + 200000t$	$P = 57680t^{0.6}$
$2\frac{1}{2}$	$P = 66500t^{0.607}$	$P = 73000t^{0.61}$	$P = 1725 + 224375t$	$P = 1870 + 237500t$	$P = 67450t^{0.6}$
3	$P = 87400t^{0.607}$	$P = 84000t^{0.607}$	$P = 2350 + 280000t$	$P = 2250 + 275000t$	$P = 76600t^{0.6}$

TABLE 5. MEDIUM HARD STEEL TRIALS.

Values corresponding to equations given in the body of the Paper and curves drawn on Figures.

With the object of presenting these results in concise form and to show at a glance the influences of speed, feed and diameter the values so deduced have been tabulated in Tables 7 and 8.

Column 1 gives the diameter of the drill; column 2 the revolutions corresponding to a speed of 48 and 60 feet per minute for cast iron and steel respectively; and column 3 gives the feed in inches per revolution for these metals and calculated from $\frac{d^{\frac{1}{2}}}{84}$ and $\frac{d^{\frac{1}{2}}}{100}$. Column 4 gives the cubic inches of metal removed per minute V.

$$V = \frac{\pi}{4} d^2 t N,$$

(where N = revolutions per minute),

$$= \frac{\pi}{4} d^2 \times \frac{d^{\frac{1}{2}}}{84} \times \frac{12 \times 48}{\pi d}$$

for cast iron,

$$= 1.715\, d^{\frac{1}{2}}$$

for cast iron,

$$= \frac{\pi}{4} d^2 \times \frac{d^{\frac{1}{2}}}{100} \times \frac{12 \times 60}{\pi d}$$

for mild steel,

$$= 1.8\, d^{\frac{1}{2}}$$

for mild steel,

The cutting horsepower column 5 is obtained by multiplying the torque for each feed and diameter of drill by $2\pi N$.

1	2	3	4	5	6	7	8
Diameter of Drill in Inches.	Revolutions per Minute $N = \frac{12 \times 48}{\pi d}$	Feed in Inches per Revolution of Drill $t = \frac{d^{\frac{1}{2}}}{84}$	Cu.In. Removed per Minute $1.715d^{\frac{1}{2}}$	Cutting Horsepower $1.16d$	Feeding Horsepower $\frac{d^{\frac{1}{2}}}{142}$	Total Horsepower.	Horsepower per Cu.In. of Metal Removed per Minute.
0.25	735	$0.0075 = \frac{1}{133}$	0.27	0.29	0.005	0.295	1.092
0.375	490	$0.0086 = \frac{1}{116}$	0.462	0.435	0.0055	0.4405	0.954
0.5	368	$0.0094 = \frac{1}{106}$	0.682	0.58	0.0059	0.586	0.862
0.75	245	$0.0109 = \frac{1}{92}$	1.17	0.87	0.0066	0.8766	0.748
1.0	184	$0.0119 = \frac{1}{84}$	1.715	1.16	0.007	1.167	0.681
1.25	147	$0.0129 = \frac{1}{77.5}$	2.32	1.45	0.0073	1.457	0.628
1.5	122	$0.0136 = \frac{1}{74}$	2.92	1.74	0.0078	1.748	0.598
1.75	105	$0.0144 = \frac{1}{69.5}$	3.63	2.03	0.0081	2.038	0.563
2.0	92	$0.015 = \frac{1}{67}$	4.32	2.32	0.0084	2.328	0.539
2.25	81.7	$0.0156 = \frac{1}{64}$	5.05	2.61	0.0086	2.619	0.519
2.5	73.5	$0.0162 = \frac{1}{62}$	5.82	2.9	0.0089	2.909	0.500
2.75	66.75	$0.0167 = \frac{1}{60}$	6.6	3.19	0.0091	3.199	0.486
3.0	61.3	$0.0172 = \frac{1}{58.4}$	7.4	3.48	0.0093	3.489	0.472
3.25	56.5	$0.0176 = \frac{1}{57}$	8.22	3.77	0.0095	3.78	0.46
3.5	52.5	$0.0181 = \frac{1}{55.4}$	9.05	4.06	0.0096	4.07	0.45
3.75	49	$0.0185 = \frac{1}{54}$	10.0	4.35	0.0098	4.36	0.436
4.0	46	$0.019 = \frac{1}{52.8}$	10.8	4.64	0.00995	4.65	0.431

TABLE 7. REVOLUTIONS PER MINUTE, FEED PER REVOLUTION, CUBIC INCHES REMOVED PER MINUTE, AND HORSE-POWER WHEN DRILLING CAST-IRON. 48 F. P. M.

Cutting horsepower in column 5.

$$C.H.P. = 1.16\, d^{1.033} = \text{say } 1.16\, d$$

for cast iron,

$$C.H.P. = 2.85\, d^{0.983} = \text{say } 2.85\, d$$

for medium steel,

The horsepower required for feeding in column 6 is obtained by multiplying the end force for each feed and diameter of drill by the feed per revolution and the revolutions per minute.

$$F.H.P. = \frac{d^{0.28}}{142} = \frac{d^{\frac{1}{3}}}{142}, \text{ say,}$$

for cast iron,

$$F.H.P. = \frac{d^{0.233}}{0.77} = \text{say } \frac{d^{\frac{1}{4}}}{77}$$

for medium steel.

having a diameter equal to the width of the chisel point of the drill to be employed. The tests were then made with different feeds and diameters of drills at a speed of 10 revolutions per minute as in the ordinary trials previously discussed.

Torque

The torques obtained in these trials have been plotted as ordinates on a base of feed per revolution on Fig. 16 and Fig. 18 for cast iron and steel respectively.

The equations to the lines drawn on the figure are given in column *b* of Table 9. These may be combined to give a general law in terms of d or $d - d_1$ and t, where d_1 is the diameter of the chisel point.

made. If the cutting pressure is worked out as in the case of the ordinary trials the difference due to chisel point will be found to be insignificant.

The general equation which most closely agrees with the modified values given in column *c* for the experiments on medium steel is,

$$T_o = 1620\, d^{1.7}\, t^{0.7}, \qquad (38)$$

and the value obtained in the ordinary trial is

$$T = 1640\, d^{1.8}\, t^{0.7}, \qquad (33)$$

or the difference in the torque due to the chisel point when operating on steel is about 1 per cent.

The values deduced from equations (37) and (38) for each size of drill are given in column *d* of Table 9.

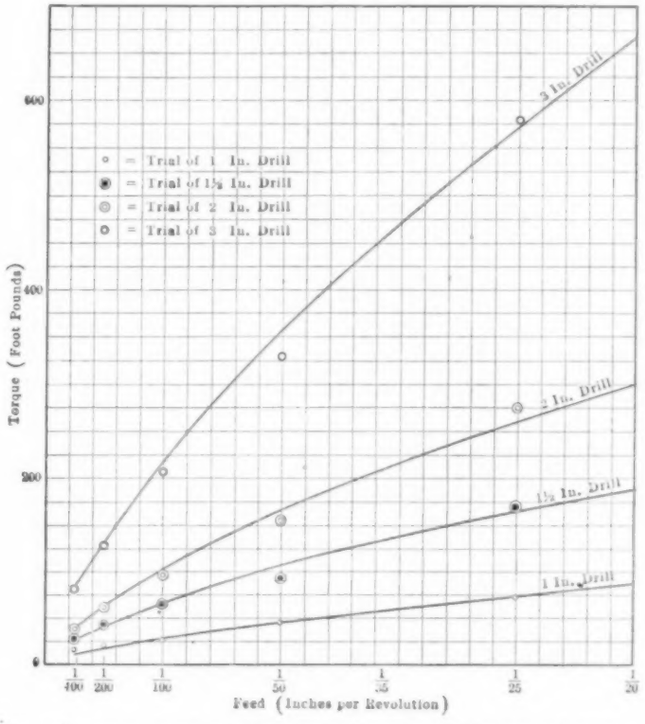

Torque (Foot Pounds)
Feed (Inches per Revolution)
= Trial of 1 In. Drill
= Trial of 1½ In. Drill
= Trial of 2 In. Drill
= Trial of 3 In. Drill
3 In. Drill
2 In. Drill
1½ In. Drill
1 In. Drill

FIG. 16. TWIST DRILL EXPERIMENTS (MINUS CHISEL-POINT) VARIATION OF TORQUE WITH FEED OPERATING ON SOFT CAST IRON

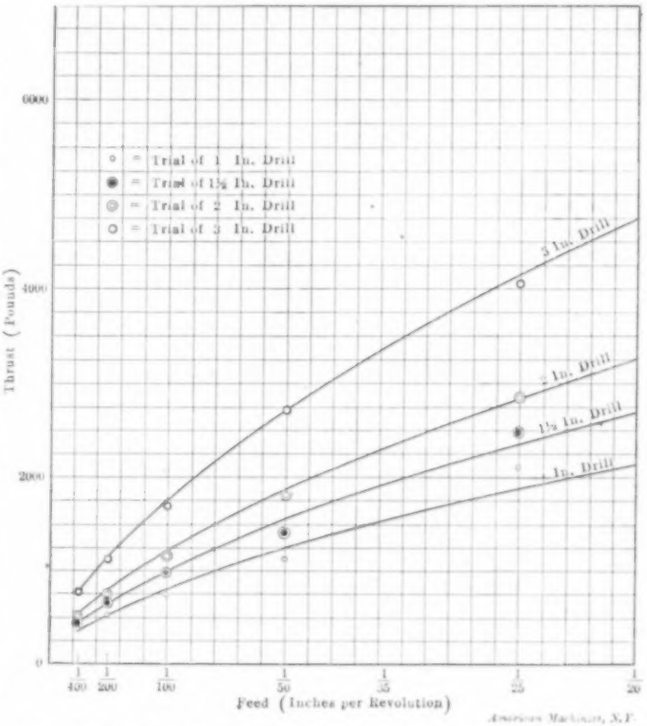

Thrust (Pounds)
Feed (Inches per Revolution)
= Trial of 1 In. Drill
= Trial of 1½ In. Drill
= Trial of 2 In. Drill
= Trial of 3 In. Drill
3 In. Drill
2 In. Drill
1½ In. Drill
1 In. Drill

FIG. 17. TWIST DRILL EXPERIMENTS (MINUS CHISEL-POINT) VARIATIONS OF THRUST WITH FEED WHEN OPERATING ON SOFT CAST IRON

Column 7 is the sum of the columns 5 and 7, while 8 is column 7 divided by column 4.

Minus Chisel-point Experiments (h) on Soft Cast Iron and Medium Steel

These experiments were undertaken with the object of determining the difference in the thrust and torque due to the chisel point of the drill. Many efforts were made at the outset to drill a hole with a chisel shaped and ground similar to that on the drill itself.

Frequent breakages, particularly when operating on steel, led to the abandonment of this procedure in favor of that where a hole was initially made in the specimen,

For comparison with the ordinary drill trials it may be more convenient to have the general equation in terms of d and t only. If the cutting pressure is desired an equation in terms of d and d_1 would be necessary. Combining the equations given in column *b* and modifying the same so that the index of t is 0.7 (see column *c*) (which is almost the average value) the general expression for the trials on cast iron is obtained.

$$T_o = 740\, d^{1.8}\, t^{0.7}, \qquad (37)$$

which is identical with that given for the ordinary trials on this metal (see equation (21). Of course, the torque in this latter set of experiments should be smaller, but the difference is so little as to be lost sight of in the approximations

Thrust

It was to be expected that the removal of a piece in the specimen equal to the chisel point width would produce a greater difference in the end thrust than in the torque. The results of these tests have been plotted in Fig. 17 and Fig. 19 on a base of feed per revolution for cast iron and steel, respectively.

The full lines drawn for the thrust correspond to the equations given in column *b* of Table 9. As in the previous cases the index of t varies very little and a constant value of 0.6 has been taken, which is about the mean of those obtained. The coefficient of t has also been altered to suit this modification and these equations are given in column *c*. Using the values of the latter a general equation as a func-

tion of d and t is got and the values deduced from the same for each size of drill are given in column d of the above table. Thus for soft cast iron,

$$P_o = 12{,}600\, d^{0.7}\, t^{0.6}. \qquad (39)$$

Comparing the latter with the ordinary trials (c) on this material there is a difference in the end force for feeds commonly used in practice of about 25 per cent., which is roughly that due to the chisel point.

The thrust for medium steel in this set of trials is as follows:

$$P_o = 27{,}000\, d^{0.73}\, t^{0.6}, \qquad (40)$$

and in the ordinary trials (f) the thrust

$$P = 35{,}500\, d^{0.7}\, t^{0.6} \qquad (36)$$

The thrust due to the chisel point in this case is about 21 per cent. of the whole drill.

Experiments Series (I)—The Variation of Torque and Thrust when Drilling Different Grades of Cast Iron

The torque and thrust obtained in these tests with a 2-inch drill have been plotted as ordinates on a base of feed per revo-

1	2	3	4	5	6	7	8
Diameter of Drill in Inches.	Revolutions per Minute $N = \frac{12\times 60}{\pi d}$	Feed in Inches per Revolution $t = \frac{d^{\frac{1}{2}}}{100}$	Cu.In. Removed per Minute $1.8d^{\frac{1}{2}}$	Cutting Horsepower $2.85d.$	Feeding Horsepower $\frac{d^{\frac{1}{2}}}{77}$	Total Horsepower.	Horsepower per Cu.In. of Metal Removed per Minute.
0.25	920	0.0063 = $\frac{1}{160}$	0.284	0.712	0.0092	0.721	2.54
0.375	614	0.0072 = $\frac{1}{139}$	0.485	1.068	0.0102	1.078	2.22
0.5	460	0.00795 = $\frac{1}{126}$	0.716	1.425	0.0109	1.436	1.99
0.75	306	0.0091 = $\frac{1}{110}$	1.23	2.14	0.0121	2.152	1.75
1.0	230	0.01 = $\frac{1}{100}$	1.8	2.85	0.013	2.863	1.59
1.25	184	0.0108 = $\frac{1}{92.5}$	2.44	3.56	0.0138	3.574	1.47
1.5	153	0.0114 = $\frac{1}{88}$	3.08	4.27	0.0145	4.285	1.39
1.75	131	0.0121 = $\frac{1}{83}$	3.81	4.99	0.015	5.005	1.31
2.0	115	0.0126 = $\frac{1}{79.5}$	4.54	5.7	0.0155	5.715	1.26
2.25	102	0.0131 = $\frac{1}{76.5}$	5.3	6.42	0.0159	6.436	1.21
2.5	92	0.0136 = $\frac{1}{73.5}$	6.12	7.12	0.0163	7.136	1.165
2.75	83.5	0.014 = $\frac{1}{71.5}$	6.92	7.84	0.0167	7.857	1.135
3.0	76.5	0.0144 = $\frac{1}{69.5}$	7.76	8.55	0.0171	8.567	1.105
3.25	70.5	0.0148 = $\frac{1}{67.5}$	8.66	9.25	0.0175	9.267	1.07
3.5	65.6	0.0151 = $\frac{1}{66}$	9.5	9.98	0.0178	9.998	1.05
3.75	61.25	0.0155 = $\frac{1}{64.5}$	10.48	10.7	0.0181	10.718	1.024
4.0	57.5	0.0158 = $\frac{1}{63}$	11.4	11.4	0.0184	11.42	1.0

TABLE 8. SPEED, FEED, METAL REMOVED AND HORSEPOWER

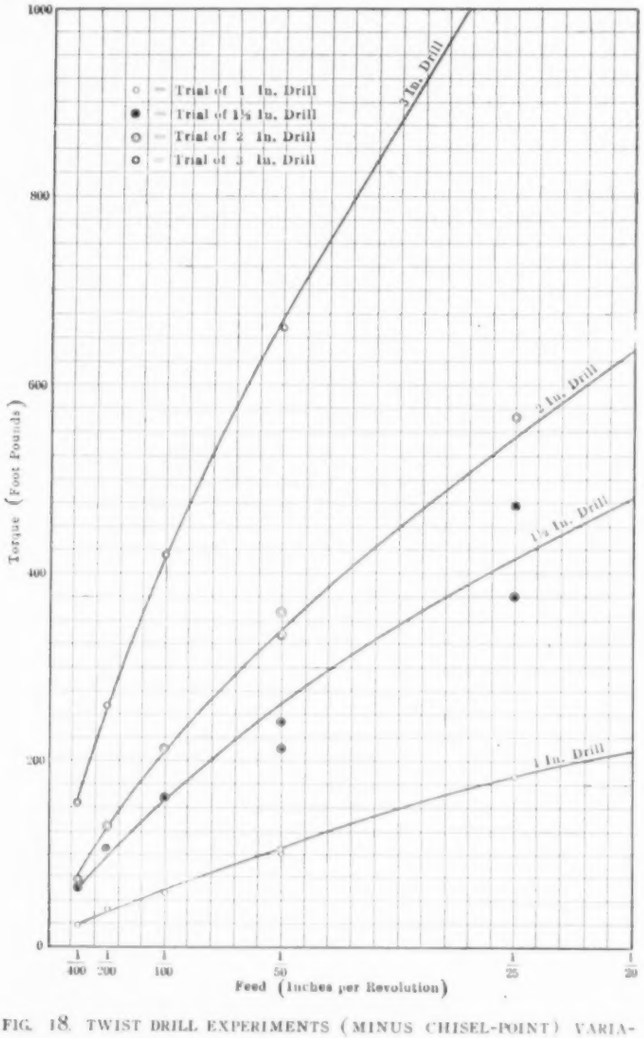

○ = Trial of 1 In. Drill
● = Trial of 1½ In. Drill
○ = Trial of 2 In. Drill
○ = Trial of 3 In. Drill
3 In. Drill
2 In. Drill
1½ In. Drill
1 In. Drill
Torque (Foot Pounds)
Feed (Inches per Revolution)

FIG. 18. TWIST DRILL EXPERIMENTS (MINUS CHISEL-POINT) VARIATION OF TORQUE WITH FEED WHEN OPERATING ON MEDIUM STEEL

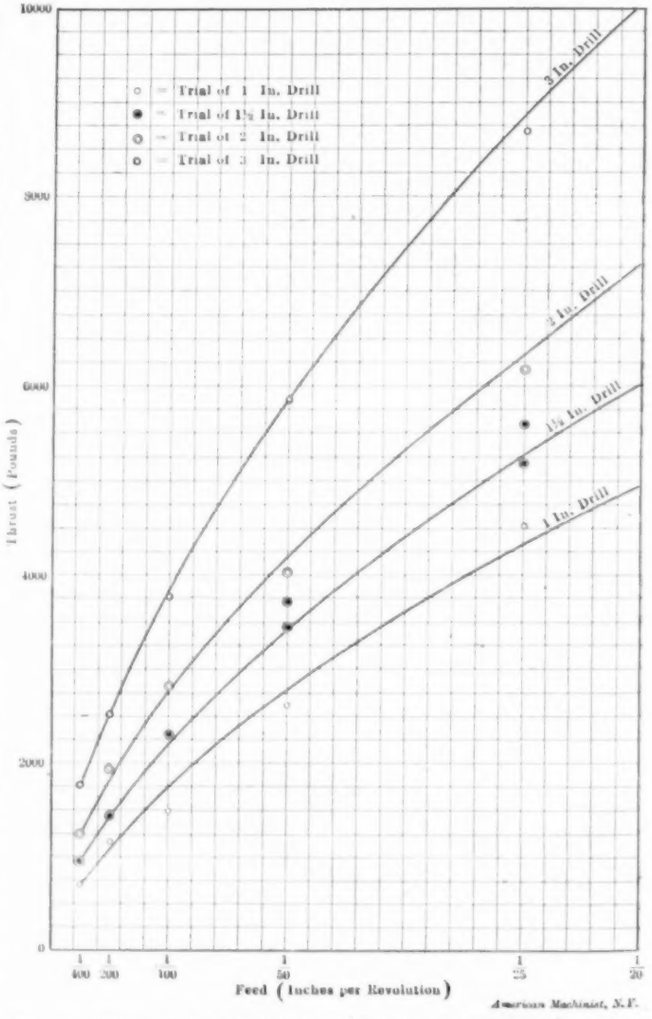

○ = Trial of 1 In. Drill
● = Trial of 1½ In. Drill
○ = Trial of 2 In. Drill
○ = Trial of 3 In. Drill
3 In. Drill
2 In. Drill
1½ In. Drill
1 In. Drill
Thrust (Pounds)
Feed (Inches per Revolution)
American Machinist, N.Y.

FIG. 19. TWIST DRILL EXPERIMENTS (MINUS CHISEL-POINT) VARIATION OF THRUST WITH FEED WHEN OPERATING ON MEDIUM STEEL

lution of drill on Figs. 20 and 21. The full lines drawn through the mean of the spots agree with the values given in columns 2 and 4 of Table 10. The diagram, however, affords the easiest means of comparing the varying physical characters of the metals. The hard cast-iron trials were not so satisfactory as the others owing to the presence of very hard spots in the specimen. These quickly destroyed the cutting edge and chisel point, so that it was impossible to get a complete set of trials without regrinding the drill. The lower spots indicate the results obtained with a freshly ground drill for each test. On the whole these experiments show that the torque and thrust increase very rapidly with the percentage of combined carbon.

Experiments (j) and (k)—The Variation of Torque and Thrust when Drilling Steel of Different Grades without and with Lubricant

These trials were made with a 2-inch drill and the results have been plotted on Figs. 20 and 21 after the manner of those already described. To avoid confusion with the spots and also to allow of an easy comparison between the dry and lubricated tests, separate vertical scales are used for each material, but the horizontal scale is common to all. The full lines drawn on Figs. 20 and 21 represent the values given in columns 2 and 4 of Table 10. With the exception of the tests on hard cast iron already mentioned and the hard steel, these trials were made under identical conditions to those previously discussed, viz.: a fresh drill was used for the 1/400 feed and the other trials made in the order of increased feed without regrinding the drill. In the case of the tests on hard steel it was impossible to get a complete set under these conditions owing to the blunting of the chisel point, and the results shown in the diagram were obtained with a freshly ground drill for each experiment. It will be observed that there is little difference between the torque and thrust for the soft and medium steel. This is, no doubt, due to the high percentage of manganese in the former. Roughly speaking the torque and thrust are practically proportional to the carbon plus the manganese for any given feed.

1	2	3	4	5
Material.	Torque. (Fig. 20).		Thrust. (Fig. 21).	
	Full lines.	Dotted lines.	Full lines.	Dotted lines.
Soft cast-iron (dry)	$2600f^{0.7}$	——	$53900f^{0.75}$	——
Medium cast-iron (dry)	$2700f^{0.7}$	——	$45000f^{0.69}$	$57000f^{0.75}$
Hard cast-iron (dry)	$290f^{0.71} + 50$	——	$45500f^{0.74} + 1500$	——
Soft steel (dry)	$4840f^{0.7}$	——	$50060f^{0.6}$	——
Soft steel (lubricated)	$6100f^{0.785}$	$4140f^{0.7}$	$56260f^{0.6}$	——
Medium steel (dry)	$5250f^{0.7}$	——	$54000f^{0.6}$	——
Medium steel (lubricated)	$9000f^{0.89}$	$3830f^{0.7}$	$54500f^{0.7}$	$36000f^{0.6}$
Hard steel (dry)	$17250f + 30$	——	$55000f^{0.6}$	——
Hard steel (lubricated)	$16750f + 15$	——	$48980f^{0.6}$	——

TABLE 10. EQUATIONS TO LINES DRAWN ON FIGS. 20 AND 21.

	Torque.		
Point angle	90°	120°	150°
Soft cast-iron	$1980f^{0.7}$	$1600f^{0.7}$	$1380f^{0.7}$
Medium steel	$4170f^{0.7}$	$3400f^{0.7}$	$2780f^{0.7}$
	Thrust.		
Point angle	90°	120°	150°
Soft cast-iron	$79000f + 250$	$1000000f + 250$	$1270000f + 250$
Medium steel	$64700f^{0.7}$	$66800f^{0.7}$	$69700f^{0.7}$

TABLE 11. EQUATIONS TO FULL LINES ON FIGS. 22 AND 23 FOR 1¼-INCH DRILL.

The lubricant used was Beckett's turning oil mixed with water in the proportion of one to fifty.

Torque. An examination of the results themselves shows that the percentage decrease in the torque due to lubrication is almost the same in soft and hard steel; also that this decrease is most conspicuous with the finer feeds. The average torque for each feed in these trials varies from 72 per cent. with the $\frac{1}{400}$ feed to 92 per cent. with the $\frac{1}{25}$ feed of that obtained when operating dry.

Thrust. The thrust for soft, medium and hard steel is 26 per cent., 37 per cent. and 12 per cent. respectively less than that obtained when operating dry. There is no marked difference in any case with

a	b	c	d
	Torque in Pounds Feet. Equations corresponding to		
Diameter of Drill, d Inches.	Full Lines on Fig. 16.	Modified Equations Not Shown on Figs.	General Law $740d^{1.8}f^{0.7}$ Not Shown on Figs.
1.0	$T_o = 630f^{0.675}$	$T_o = 680f^{0.7}$	$T_o = 740f^{0.7}$
1.5	$T_o = 1325f^{0.65}$	$T_o = 1710f^{0.7}$	$T_o = 1535f^{0.7}$
2.0	$T_o = 2180f^{0.66}$	$T_o = 2625f^{0.7}$	$T_o = 2580f^{0.7}$
3.0	$T_o = 5250f^{0.69}$	$T_o = 5500f^{0.7}$	$T_o = 5330f^{0.7}$
	Thrust in Pounds. Equations Corresponding to		
Diameter of Drill d Inches.	Full Lines on Fig. 17.	Modified Equations Not Shown on Figs.	General Law $12600d^{0.7}f^{0.6}$ Not Shown on Figs.
1.0	$P_o = 13180f^{0.607}$	$P_o = 12792f^{0.6}$	$P_o = 12600f^{0.6}$
1.5	$P_o = 16600f^{0.607}$	$P_o = 16120f^{0.6}$	$P_o = 16730f^{0.6}$
2.0	$P_o = 19950f^{0.607}$	$P_o = 19372f^{0.6}$	$P_o = 20450f^{0.6}$
3.0	$P_o = 29170f^{0.607}$	$P_o = 28320f^{0.6}$	$P_o = 27200f^{0.6}$
	Soft Cast-Iron Trials.		
a	b	c	d
	Torque in Pounds Feet. Equations Corresponding to		
Diameter of Drill, d Inches.	Full Lines on Fig. 18.	Modified Equations Not Shown on Figs.	General Law $1620d^{1.7}f^{0.7}$ Not Shown on Figs.
1.0	$T_o = 2000f^{0.746}$	$T_o = 1616f^{0.7}$	$P_o = 1620f^{0.7}$
1.5	$T_o = 3700f^{0.679}$	$T_o = 4042f^{0.7}$	$P_o = 3225f^{0.7}$
2.0	$T_o = 5200f^{0.701}$	$T_o = 5184f^{0.7}$	$P_o = 5270f^{0.7}$
3.0	$T_o = 10600f^{0.705}$	$T_o = 10380f^{0.7}$	$P_o = 10470f^{0.7}$
	Thrust in Pounds. Equations Corresponding to		
Diameter of Drill, d Inches.	Full Lines on Fig. 19.	Modified Equations Not Shown on Figs.	General Law $27000d^{0.732}f^{0.6}$ Not Shown On Figs.
1.0	$P_o = 36000f^{0.659}$	$P_o = 27460f^{0.6}$	$P_o = 27000f^{0.6}$
1.5	$P_o = 40000f^{0.63}$	$P_o = 34880f^{0.6}$	$P_o = 36300f^{0.6}$
2.0	$P_o = 42500f^{0.592}$	$P_o = 44192f^{0.6}$	$P_o = 44800f^{0.6}$
3.0	$P_o = 60000f^{0.593}$	$P_o = 61900f^{0.6}$	$P_o = 60300f^{0.6}$
	Medium Steel Trials.		

TABLE 9. MINUS CHISEL POINT TRIALS.
Values corresponding to equations given in the text and curves drawn on Figs. 16 and 17.

these percentages and the feed as in the torque.

Experiments Series (L) and (M). The Variation of Torque and Thrust with Angle of Drill Point when Operating on Cast Iron and Steel

In this set of trials the included angle θ only was altered; the pitch, chisel point, etc., see Fig. 4, remaining as in previous tests and given in Table 3. The results obtained have been plotted on Figs. 22 and 23 and full lines are drawn through the mean of the spots for each set. Equations to the strong full lines for the 1½-inch drill only have been attempted and these are given in Table 11. With the exception of the thrust on cast iron the characters are generally alike.

Torque. An alteration of the point angle would be expected to alter the torque since it also alters the plane in which the shavings leave the work; i.e., the true cutting angle. The mean cutting angles for these drills have been obtained by the method described and are given in Table 12. Since the cutting pressure is proportional to the cutting angle, the torque for a given diameter of drill and feed is also proportional to it. By dividing the coefficient of t in Table 11 by the cutting angle the quotient should be a constant. This, however, is not the case (see lines 6 and 7, Table 12) and the variable quotient can only be attributed to a bluntness effect which is proportional to the length of the cutting lip. The length of the lips are equal to

$$\frac{d - \textit{chisel point}}{\cos.\left(90 - \frac{\theta}{2}\right)};$$

(1) Point angle	90°	120°	150°
(2) Cutting angle of lip and backed off portion	89.2	72.8	65.5
(3) Cutting angle of chisel point	13.0	14.4	15.8
(4) Cutting angle (total)	102.2	87.2	81.3
(5) Length of lip and backed off portion	$\frac{0.904 \times 0.75}{0.707} = 0.96$	$\frac{0.904 \times 0.75}{0.866} = 0.782$	$\frac{0.904 \times 0.75}{0.966} = 0.71$
(6) Coefficient of t for torque in cast-iron / Total cutting angle	$\frac{1980}{102.2} = 19.4$	$\frac{1540}{87.2} = 17.7$	$\frac{1380}{81.3} = 17$
(7) Coefficient of t for torque in steel / Total cutting angle	$\frac{4170}{102.2} = 41$	$\frac{3400}{87.2} = 39$	$\frac{2780}{81.3} = 34.2$
(8) Cosine β	0.707	0.866	0.966
(9) Coefficient of t for thrust in steel	64700	66800	69700
(10) Thrust due to chisel point $= \frac{21 \times 66800 \times \text{Cos. } \beta}{100 \times \text{Cos. } 30°}$	11450	14000	15800
(11) Thrust due to the lip = (9)–(10)	53250	52800	53900

TABLE 12. CUTTING ANGLES AND COEFFICIENTS FOR DRILLS INCLUDED ANGLE, 90,120, AND 150 DEGREES, RESPECTIVELY.

and are given in line 5 or Table 12, from which it will be seen that they are in the order of the quotients above.

Thrust. It will be noticed that the values for the thrust are in the order of the included angle and exactly the reverse of those for the torque. That the drill having the keenest cutting angle should give the greatest backward thrust may appear at first glance to conflict with the results obtained in the "Experiments with a Lathe-Tool Dynamometer" and common experience. It must be remembered, however, that the drill having the least lip angle has also the greatest adverse chisel-point angle. Two distinctly opposite effects, therefore, enter this quantity, and the experiments are insufficient to assign a value to each. The minus-chisel point when compared with the ordinary trials give the effect due to the chisel point for a common cutting angle. The amount due to the chisel point was found to be about 25 per cent. and 21 per cent. of the thrust for the whole drill

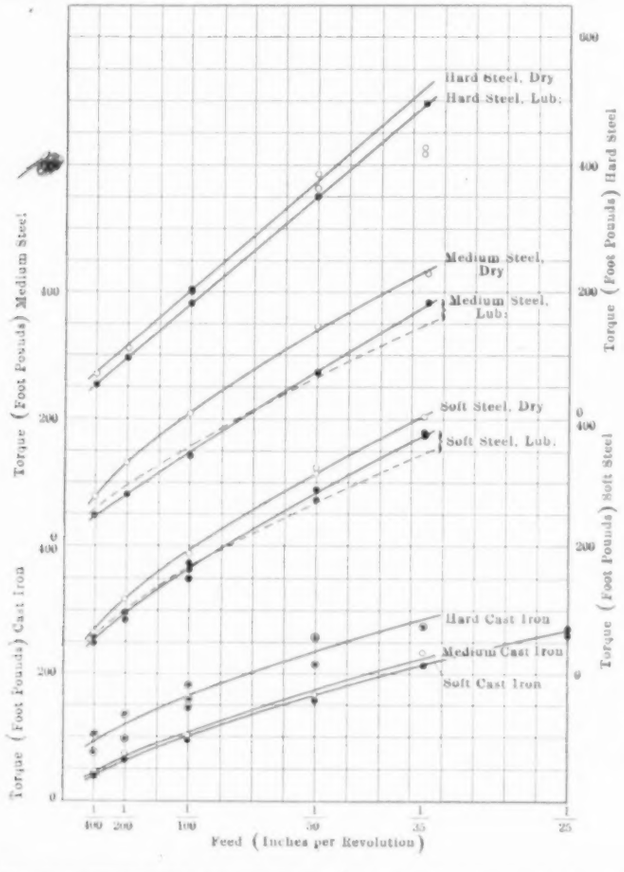


FIG. 20. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF TORQUE WITH FEED WHEN OPERATING ON STEEL AND CAST IRON WITH 2-INCH DRILL

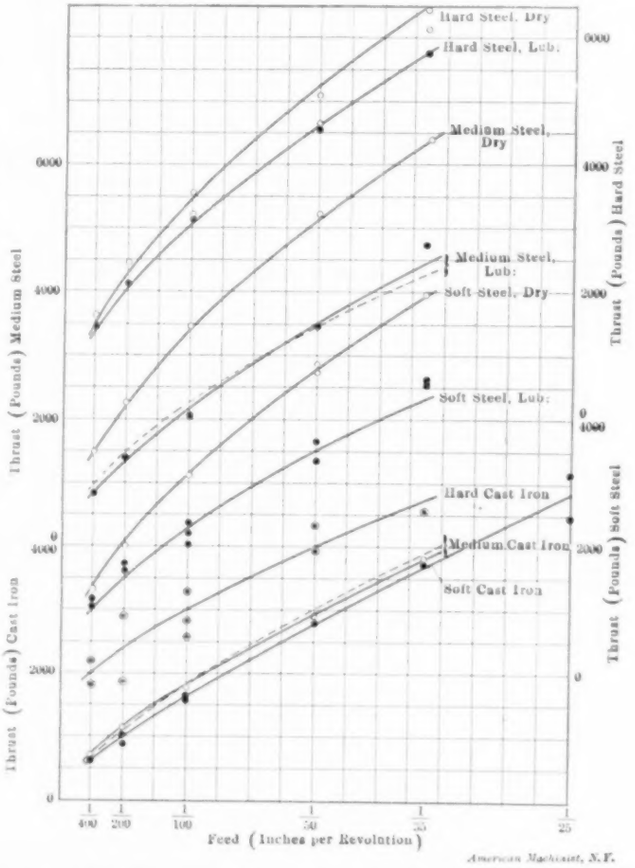


FIG. 21. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF THRUST WITH FEED WHEN OPERATING ON STEEL AND CAST IRON WITH 2-INCH DRILL

in cast iron and steel respectively while the chisel point is barely 10 per cent. of the drill diameter. For drills with included angles other than 120 degrees it is reasonable to suppose that the value due to the chisel point should vary as

$$sin.\frac{\theta}{2} \quad i.e.\ cos.\,\beta\,;$$

see Fig. 4. It would be expected that if the quantity thus derived is subtracted from the total thrust the remainder should be a value decreasing somewhat with the cutting angle of the lip. This answers fairly well with the steel trials but is very far out with the results obtained in the cast-iron tests.

Fig. 22. The results given above are the outcome of over one thousand tests.

It will be gathered from what has been said earlier in this paper that the conception of these experiments is due to Dr. J. T. Nicolson. To him the authors here offer their best thanks for the many valuable hints in making the tests the outcome of an extended experience in this field of work.

Conclusions

(*a*) The horsepower for a given diameter of drill and feed is proportional to the revolutions or the cutting speed.

(*b*) The horsepower $\left(\frac{2\pi NT}{33{,}000}\right)$ is proportional to the torque, and for a given drill and speed does not increase as fast as the feed [see equations (4) and (9)].

(*c*) Since the torque is practically proportional to the diameter of the drill squared, the horsepower, for a given feed and cutting speed, is directly proportional to the diameter of the drill [see equations (4) and (9)].

(*d*) The horsepower per cubic inch of metal removed is inversely proportional to the feed and independent of the drill and cutting speed [see equations (4) and (9)].

(*e*) The work required to drill a given hole, when one drill only is used, is greater than that required to drill the same hole in two operations with drills of different diameters. The greater the difference in the drill diameters, the greater the saving in work; speed and feed remaining the same throughout. This is due to the fact that the mean cutting angle of the single drill is greater than the average angle in use for the two drills and that the stress is proportional to the angle [see equations (10), (11) and (12)].

(*f*) With twist drills having the usual proportions (similar to those given in Table 1), the cutting angle is not sufficiently keen to drag the drill into the work when enlarging a hole in cast iron or steel [see equations (13) to (15) and (18*a*) to (18*c*)].

(*g*) Conclusion (*b*) confirmed. The horsepower when operating on soft cast iron or medium steel varies as $t^{0.7}$ for a given drill and speed [see equations (21) and (33)].

(*h*) The horsepower for a given feed and speed does not increase as fast as the diameter but varies as $d^{0.8}$ [see equations (21) and (33)].

(*i*) The torque and horsepower when

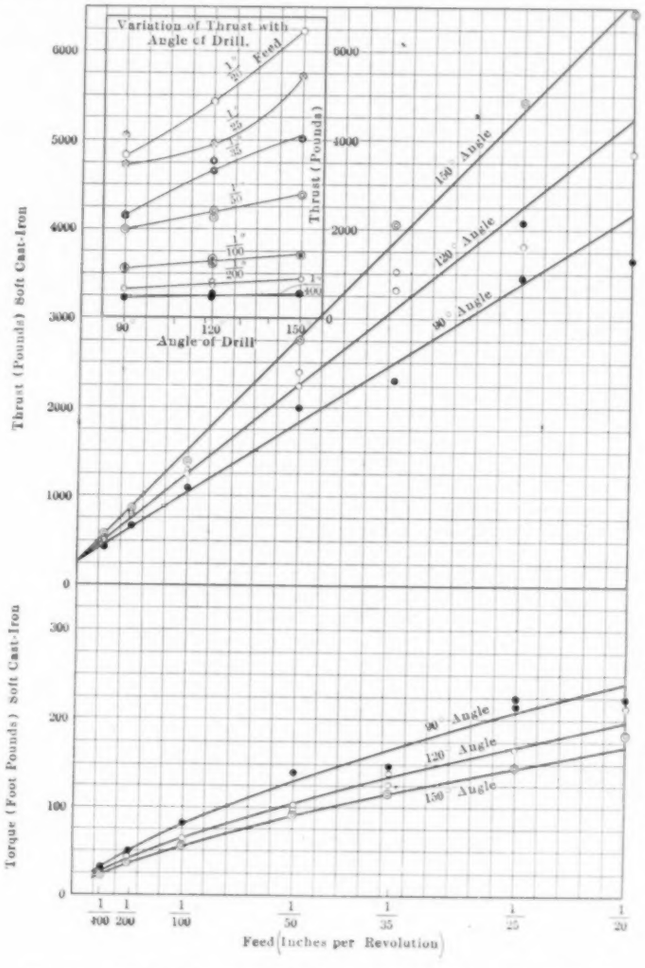


FIG. 22. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF TORQUE AND THRUST WITH FEED WHEN OPERATING ON SOFT CAST IRON FOR VARIOUS ANGLES OF DRILL

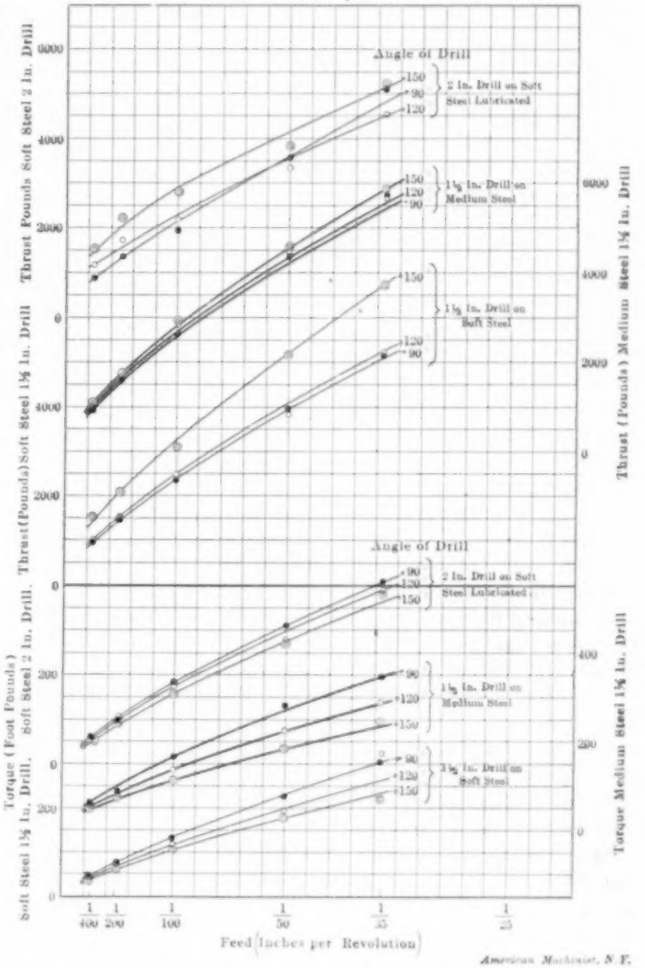

Angle of Drill
2 In. Drill on Soft Steel Lubricated
1⅝ In. Drill on Medium Steel
1⅝ In. Drill on Soft Steel
Thrust Pounds Soft Steel 2 In. Drill
Thrust (Pounds) Medium Steel 1⅝ In. Drill
Torque (Foot Pounds) Soft Steel 1⅝ In. Drill. Soft Steel 2 In. Drill.
Torque Medium Steel 1⅝ In. Drill
Feed (Inches per Revolution)
American Machinist, N. Y.

FIG. 23. TWIST DRILL EXPERIMENTS (ORDINARY) VARIATION OF TORQUE WITH FEED WHEN OPERATING ON STEEL, FOR VARIOUS ANGLES OF DRILL

Owing to the results of the steel tests coming so closely together they were repeated. The drill used in the latter set was soft at the point and the 90-degree tests fell on the top of the 120 degrees owing to the former blunting at the point. A set with the 2-inch drill was, therefore, made and a strong stream of lubricant was used to give the 90-degree drill every chance of standing up to the work.

The results obtained in the tests on cast iron have also been plotted on a base of point angle at the left-hand corner of

drilling medium steel is about 2.1 times that required to drill soft cast iron with the same drill speed and feed.

(*j*) The horsepower per cubic inch of metal removed is inversely proportional to $d^{0.2}\ t^{0.3}$ and independent of the revolutions. Thus the horsepower per cubic inch of metal

$$\frac{4 \times 2\pi N c d^{1.8} t^{0.7}}{33{,}000\ \pi d^2 t N} = \frac{k}{d^{0.2} t^{0.3}},$$

where c and k are constants.

If d remains constant and feeds of $\frac{1}{400}$ inch, $\frac{1}{100}$ inch and $\frac{1}{25}$ inch be taken, the corresponding horsepowers will be in the order of 1, 0.66 and 0.435 which is in the order of the pressures given on pages 30 and 32. If t remains constant and values $d = \frac{1}{2}$ inch, 2 inches and 4 inches be taken, then the horsepower for each successive drill will be in the order of 1, 0.76 and 0.66.

(*k*) The power required to enlarge a hole may be estimated from the pressures given by equation (25*a*) for cast iron and 2.1 times that value for medium steel.

(*l*) In a two-lipped drill the actual depth of cut taken by each lip is $\frac{t}{2}$; in a three-lipped drill $\frac{t}{3}$; and so on.

If the number of lips is increased, and t kept the same the pressure produced is equivalent to that for a proportionately decreased feed.

If the lips are unequally ground, so that the one lip does all the work the cutting pressure is the same as that obtained by doubling the feed.

By gashing the lips of the drill in such a manner that the cut taken by one lip is the metal left by the other, the pressure is the same as that given for twice the feed.

It is shown on pages 30 and 32 that the finer the feed the greater the cutting pressure and consequently the horsepower per cubic inch of metal removed.

(*m*) The end thrust when operating on cast iron or steel does not increase in proportion to the feed for a given diameter of drill or in proportion to the diameter for a given feed.

(*n*) While the chisel point scarcely affects the torque it is accountable for about 20 per cent. of the end thrust.

(*o*) The lubricated trials on steel when compared with the dry tests show a diminution in the torque and horsepower, varying from 28 per cent. with the $\frac{1}{400}$ feed to 8 per cent. with the $\frac{1}{25}$ feed. This may be due to the lubricant washing away the small metal chips which tend to jam between the walls of the hole, and the drill, and to the preserved cutting edge. The diminished frictional resistance of the shaving across the lip together with above reduces the end thrust by about 25 per cent. for all feeds.

(*p*) The drill most commonly adopted in practice has an included angle at the point of 120 degrees. If this angle is increased the torque diminishes but the end thrust increases, while if this angle is decreased the reverse is the result. So far as economy in power is concerned the torque is the factor to consider, as the feeding horsepower is only about 1 per cent. of the whole in small drills and very much less for the larger sizes (see Tables 7 and 8). From this point of view the drill with the larger point angle is to be preferred. The accompanying increased end thrust, however, strains the machine parts in proportion. When the point of the drill breaks through the metal at the bottom of the hole, a considerable portion of the end load is removed. The strain due to that load is released, thereby causing the drill to advance more than its rated feed and possibly break the drill. The drill with the greater included angle will be most likely to give trouble in this direction, both on account of the increased strain and torque and conversely.

(*q*) By decreasing the spiral of the drill a keener cutting angle with a decreased end thrust and torque can be obtained without altering the point angle above the accepted standard, 120 degrees. This, however, would in turn affect the durability of the drill.

(*r*) With a small included point angle there is little metal to support the cutting edge at the chisel point, and trouble due to blunting of this part is to be expected.

(*s*) In estimating the time required to drill a hole of given depth the length of the drill point must be taken into account. The length of the point for different included point angles is:

90 degrees = 0.5*d*
120 degrees = 0.29*d*
150 degrees = 0.134*d*.

An Indexing Drill Jig

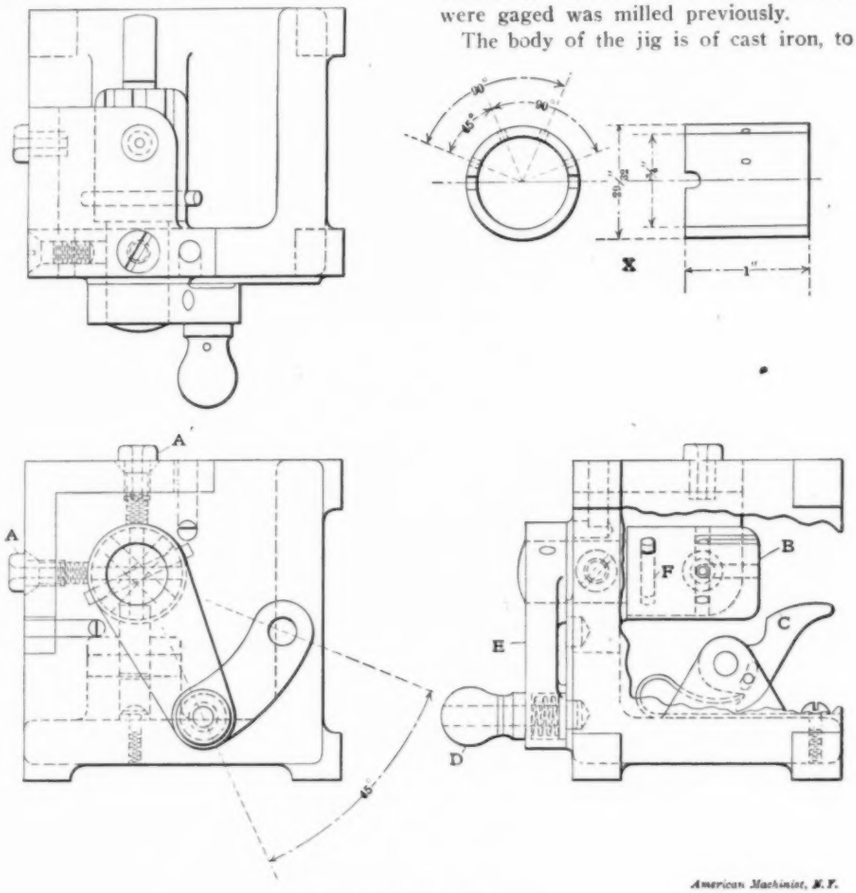
By W. R. Humelbaugh

At *X* is shown the piece to be drilled and the location of the holes, which, as indicated, are at angles of 45 degrees with each other. The slot from which the holes were gaged was milled previously.

The body of the jig is of cast iron, to which is fastened and doweled the bushing plate, with the bushings *A* and *A'* at right angles.

As the work is slipped upon the arbor *B* the latch *C* is depressed, snapping back and locking the work as soon as it is gaged by the pin *F*. The work is locked upon the arbor firmly enough for drilling but not so firmly that it cannot be readily revolved by the lever *E* after the first two holes are drilled.

Of course, the holes are drilled alternately, the first and third, then the second and fourth, or *vice versa*, whichever hole the spring pin *D* happens to be engaged in when the work is placed in the jig.



American Machinist, N.Y.

AN INDEXING DRILL JIG

Practical Letters from Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

Some Planing Fixtures

Being unfortunate enough at one time to have the management of some small workshops in which milling was unknown, I had to devise a set of fixtures, which are not without interest.

There were numbers of "frogs," or indent plates to be made of brass of a shape shown in the drawing, Fig. 1. They had to be perfectly sharp at the edges and machined all over. These frogs were used to make the indents in pressed bricks to form a key for the mortar, and for this purpose they were fixed onto cast-iron die plates, the size of the "green" bricks.

It was a private works with some 40 hands, but we had to compete with estimates from other firms, and the frogs had to show a profit over those made by means of milling machines. They are not easy things to hold at all without damage in some form or other, especially when machining the under side.

I made a set of three planing fixtures to perform the operations as follows:

1. Machine the under side *A*.
2. Machine the long V-sides *B B*.
3. Machine the short V-sides *C C*.

Each fixture was made to hold six frogs at once.

To start with, the six castings were made tandem joined end to end by webs, as in Fig. 2, and in the under side *A* of each was cored a hole to take a bolt head. This hole was no detriment, as this was the side that was placed next to the die plate.

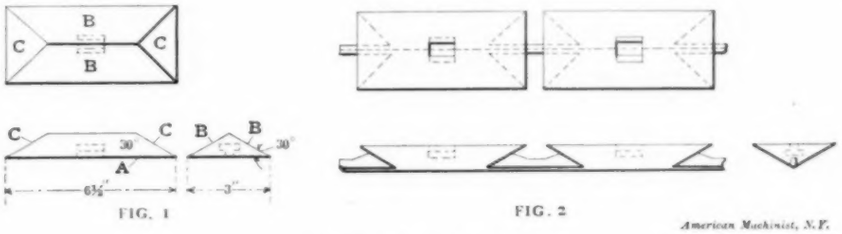


FIG. 1

FIG. 2

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THE WORK TO BE PLANED

Fig. 3 shows in three views the fixture for operation 1, for machining the under side *A*. It consists of a casting of suitable length with an inverted V planed in it to take the casting. At the ends of each casting is a holding-down arrangement consisting of a bar placed across each of the junction webs and clamped by a thumb screw.

There was one fault with this fixture that proved to be a virtue. Owing to the clamping devices not being exactly over the points of support, the work, when planed, was concave in its length, that is to say, each frog was concave. This proved to be a good thing, for when the frogs were fastened onto the die plates, the screws pulled their edges very snugly onto the plates.

Fig. 4 shows in three views the fixture for performing operation 2, planing the long V-sides of the frog. It consists of a hexagon bar with a flat planed as wide as the side *A* of the work and long enough to take the string of six castings. On the side of the bar opposite this flat there are two sets of three flats, the middle one of which is parallel with the flat carrying the frogs, and the other two are at an angle equal to the desired angle on the frogs. These two sets of flats in turn are placed and clamped in V-blocks at each end. The clamping of the bar in the V-blocks is accomplished by means of an eccentric and strap, which in half a turn raise the bar sufficiently to enable it to be turned by hand, so that when it is reclamped it seats itself on the other set of flats. This enables the two sides of the

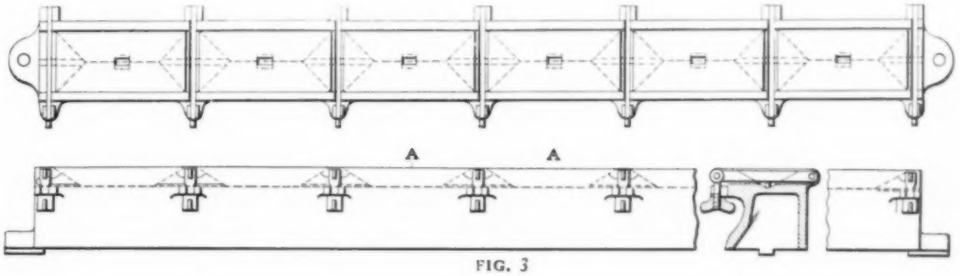
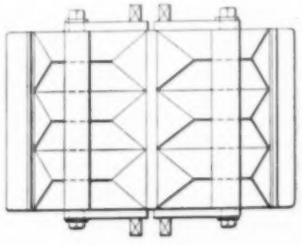


FIG. 3



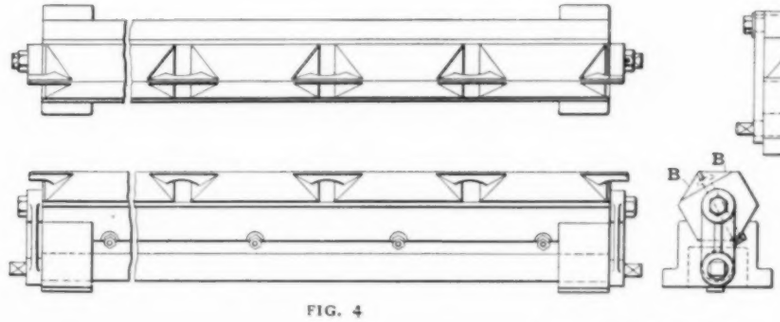


FIG. 4

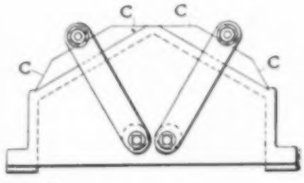


FIG. 5

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THE PLANING FIXTURE

V's to be machined at one setting of the work.

With this fixture the work is clamped by special bolts with heads suitable to engage with the holes cored in the under side *A* of the castings, so that when they are clamped the surface *A* which, by the former operation, was made concave, is sprung flat again while on the fixture.

It will be noted that each side of the long V should be machined with one setting of the cutting tool to keep the work central. Also by setting the tool to a fixed hight the castings are kept to one size. After this operation the six castings are placed under the hack saw, and the junction webs are cut off. Fig. 5 shows also in three views the fixture for operation 3, that is, machining the ends of the frogs.

This operation was performed on the shaping machine. There are three frogs clamped on either side. One side is so adjusted that the correct amount is removed from one end of the frog, locating from the rough casting on the other end. The other side is so adjusted that the correct amount is removed from the other end, locating from the finished end. In this way, while one set of three is being machined, the other three can be set and *vice versa*. The clamping on this fixture is done by eccentric straps with yoke bar lined with leather.

These fixtures made the frogs all of one size without any measurement, simply by setting the tool to a setting block, which formed a part of the fixtures. In operation 1 the setting point was the top of the fixture casting; in operation 2 the setting point was the bar itself, the flat being of the width desired for the frog, and in operation 3 the setting point was the apex of the fixture casting. The work was turned out in excellent shape and good time.

It was suggested that a better way of making this indent in the bricks would be to form the frog as part of the die plate; but although it is done in some cases, it is not as satisfactory in practice, because brass is a better conductor of heat than cast iron or steel of which the die plates are made. This is important because when the clay is under pressure it is more or less adhesive, and the heads onto which the die plates are fastened have to be steam-heated to prevent the clay from sticking to the plates, and these frogs being of considerable depth are not so easily kept at the required temperature.

Manchester, England. B. A. EDDY.

A Depth Indicator

In many machine shops considerable work will be found similar to Fig. 1 involving the machining of caps and bearings, or pieces abutting and matching at shoulders. In some of these shops no good method of measuring the work with precision is known. To facilitate such operations the indicator herewith illustrated was designed.

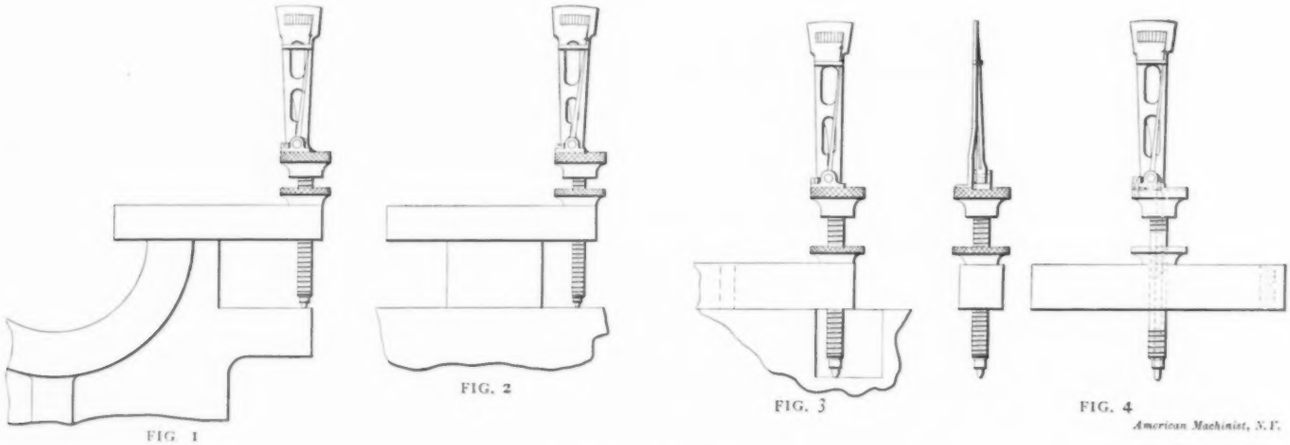

FIG. 1 FIG. 2 FIG. 3 FIG. 4

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A DEPTH INDICATOR

Figs. 1 and 2 show the application of the indicator, which is first tried on a standard-size block, as shown in Fig. 2, then transferred to the work, as in Fig. 1, showing at once how much metal must be removed from either surface under consideration. This indicator also transfers dimensions nicely in finding the depth of holes, as in Fig. 3.

The construction of the indicator is shown in Fig. 4. The threaded sleeve is drilled and reamed to receive the plunger which is pressed against the short arm of the indicator needle by means of a small, flat spring; against the long arm of the needle is another spring, and the plunger and needle are thus kept in constant contact with each other. The short arm is ⅛ inch, the long arm 1 15/16 inches, and the needle thus travels 1/64 inch on the scale to represent 0.001 inch movement of the plunger.

Brighton, Mass. F. RATTEK.

A New Method of Straightening Machine Tables and other Pieces of Metal Which Have Become Warped by Peening

It is a fact well known to mechanics that machine tables become more or less warped by bolting work and the laying or dropping, more or less gently, of tools, clamps, fixtures, etc., on them. These cause distortion by peening the upper surface, thus stretching that part, and as the under part is not subjected to such action the whole table becomes bowed so that fixtures cannot be properly located or secured.

The usual way to correct tables which are distorted in this way is to remove the peened surface. But this is poor practice, because after each planing the table is thinner and less able to withstand the strain of subsequent peenings.

The new method was discovered by E. J. Armstrong, superintendent of the Ball Engine Works, Erie, Penn. It was first tried by him on shafts which had been subjected to peening action and these were so successfully straightened that when I was in Erie recently he decided to try to straighten the table of a heavy, plain, milling machine which was badly bent after about six years' hard service. The beauty of this new method of straightening is that no metal is removed and the piece will return to its original shape; that is, if it was straight originally it will, after treatment, be straight. It is not possible to overdo the process and bow the tables in the opposite direction.

The table which I saw straightened was 4 feet long by 16 inches wide. It had become so bowed that it was very difficult to move it in the saddle. This machine had been built along the lines laid down by Professor Sweet; the saddle was the same length as the table. After considerable trouble it was removed from the saddle

and a straight-edge and thickness gages showed it to be about 0.026 high in the center. Turning it over and testing on the inside showed it to be the same amount hollow in the center, so we assumed it to be that much out of true.

The first job was to remove the table to the blacksmith shop, as the straightening was to be done there.

Wood strips were obtained from the pattern shop a snug fit for the T-slots and just the length of the table. These were driven into the T-slots and pieces fitted to the ends and secured to the long strips by nails. Finally pieces were fitted along the sides, making a trough on the top divided into four smaller troughs by the pieces of wood in the three T-slots. The cracks between the table and the wooden pieces were then filled up with plastic clay and the clay oiled so as to prevent the metal from sputtering. Two pigs of lead were put into a large ladle to melt while the table was being leveled up.

After the metal was melted it was poured all over the upper or peened surface of the table to a depth of about ½ inch and the whole thing allowed to cool until the lead was thoroughly set. The lead was then removed and the table was allowed to cool. On reaching the temperature of the atmosphere a careful test with straight-edge and thickness gages showed the original camber of 0.026 to have been reduced by about 0.006. This, while not a brilliant success, was encouraging, and the table was removed to the large floor plates where the engines are bolted during the testing operation. Here the two ends of the table were placed on parallel strips, the wooden pieces again fitted exactly as they had previously been in the blacksmith shop. As a further precaution two bolts and clamps were fitted to two T-slots in the floor plates and two clamps were fitted with heels on top of the table about the center of its length. A strain was put on the nuts and the clamps drawn down enough to bend the table beyond straight enough to permit a thickness of paper, about 0.003 thick, to go under the middle of the straight-edge. By this time the lead was ready. This time the metal was a good, red heat, which was considerably hotter than it was on the previous occasion. The pouring was done in the same manner that it was done on the previous occasion, but the whole of the two pigs were used covering the whole surface to a depth of about 1 inch. The pour was made just before quitting time and the whole affair, lead and all, allowed to cool over night. The next morning the table was found to be dead true.

Apparently the melted lead heats and softens temporarily the strained surface, and while in this condition the strains get a chance to relieve themselves.

New York. E. A. DIXIE.

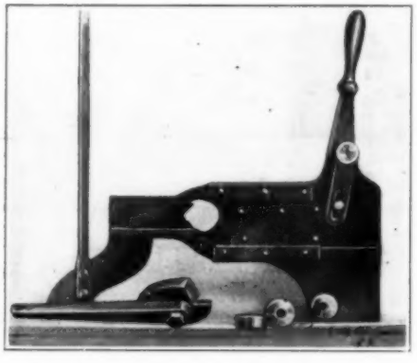


FIG. 1. THE FIXTURE FORMING TOOL AND ROLLERS

Tools for Turning Rollers

Having quite a number of variable speed transmission devices of a well known type in active operation I noticed that the thrust rollers were the main parts to wear, there being about seventy to replace in the course of six months' running. These rollers are of tool steel, 1 3/16 inches diameter, one end being flat, the other end oval to conform to bearing. There is also a ⅜-inch hole through the center. After hardening they are ground true on outside. The cost of the rollers is 21c. each, making a total cost for seventy rollers $14.70. Thinking it possible to cut this cost down I devised the following fixtures and tools to go on one of our 14-inch lathes having a 1¼-inch hole through the spindle. The fixture for holding the work steady and cutting off is bolted to the carriage. The cutting off tool is ⅛x¾-inch Novo steel in a slide operated by a handle; the handle being preferred to a screw as there is a chance of the work tearing and breaking the tool if there is no give to the feed. The back rest consists of a piece of hardened ½x1-inch tool steel with a V in the end. The cap screw to hold this is in a slot to allow variations in diameter of the stock. The forming tool is held in the tool post. It is securely fastened to a piece of ½x1-tool steel, by a half-inch nut and stud with a left-hand thread. The same holder can be used for different formed tools on other work. The drill is held in a socket in the tail spindle. The roller is drilled, formed and cut off without changing tools, the operation being repeated until the fixture is too close to the chuck. The chuck is then loosened and the stock slid further out. Fig. 1 shows the fixture, the forming tool and three rollers. The rollers after being turned and cut off are hardened and are then slipped onto an arbor in the live spindle of lathe. The tail center is then brought against it, the friction holding the roller in place. The lathe is not stopped during this operation. A small emery wheel, in a fixture on the compound rest, driven from a pulley overhead is then passed across the face of the roller and the job is finished. The cost of seventy rollers was as follows: 4 feet of tool steel, weight 15 pounds, at 10 cents per pound, $1.50; labor for turning, cutting off, etc., $1.40; power, 60 cents; hardening and grinding, 45 cents, making a total cost of $3.95 against $14.70 for seventy rollers.

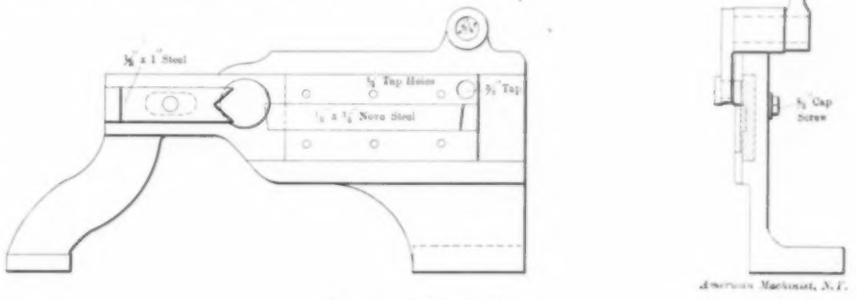


FIG. 2. THE FIXTURE

The cost of the fixtures is not taken into account, these being used over again. The entire fixtures and tools cost $11.80.

Newburgh, N. Y. GEO. H. HANDLEY.

Infant Industries

Speaking of steel trusts and other infant industries and their proper protection and encouragement while young and helpless, here are a few old daguerreotypes of interest. It sometimes does a fellow good to stop and look at his first likeness and wonder if it is true.

The Franklin Institute offered the following prizes, among many others, to be awarded at the exhibition in 1826:

"To the maker of the best cast steel manufactured in any state of the Union; A specimen of at least ten pounds in bars of one half inch square or smaller must be exhibited; with a certificate that at least *one hundred pounds* have been made. The quantity of the steel and the neatness of the bars to be considered in estimating its merit. A silver medal."

"To the manufacturer of the best white lead, fifty pounds to be exhibited,—A

silver medal. Assurance must be given that *20 tons* will be furnished of the same quality at the same price."

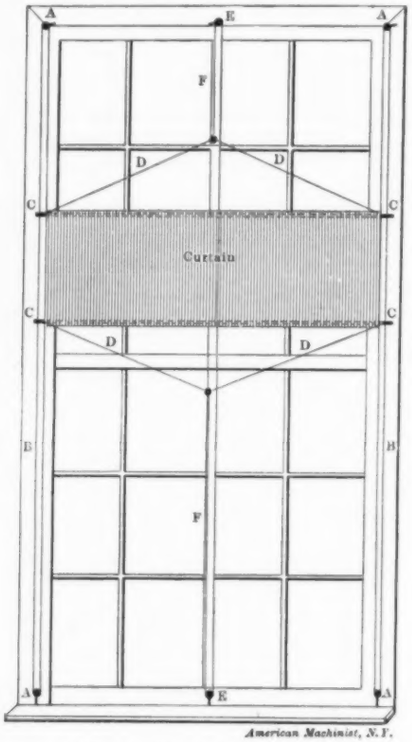
"To the person who shall have manufactured in Pennsylvania, the greatest quantity of iron from the ore, using no other fuel but anthracite, during the year ending Sept. 1st, 1826. The quantity to be not less than 20 tons. A gold Medal."

Urbana, Ill. E. W. FISKE.

To Protect Workmen's Eyes from the Glare of the Sun

The object of this device is to protect the eyes of the workmen from the glare of direct sunlight, and at the same time, not to materially interfere with the light.

I have often noticed, that while some of the men in the shop were working at the machine so situated, they received a glaring light from the sun at certain



THE ADJUSTABLE SUN SHADE

hours of the day, other men only a few feet away, were not so affected at that same time, as the angle at which the sun was shining brought its direct rays to bear on one machine, leaving the machine a few feet away all right.

Now as this process of the sun shifting is constantly going on, it is quite plain that any means whereby its direct rays, with the attendant glare can be controlled, will be much appreciated.

The accompanying cut illustrates the device.

I would advise four screw-eyes *A* to be placed in the positions shown in the drawing, at top and bottom of window frame. A small copper wire *B* passed through the screw-eyes and brought together, making a continuous loop will act as a guide to the upper and lower cross-bar *C C*.

Now take a strip of unbleached muslin as wide as the window and 24 inches long, make a hem at top and bottom of the shade wide enough to admit the ordinary shade stick. Attach a copper wire *D* to this as shown in the drawing. Fasten a stout twine to this copper wire, and pass it over a small pulley *E* screwed into the center of the window frame at the top and a corresponding pulley screwed into the frame work of the window sill at the bottom. Attach the cord *F* as shown in the drawing, carry it over the top pulley, through the lower pulley and up to the copper wire *D* which is attached to the lower cross-bar of the curtain *C*.

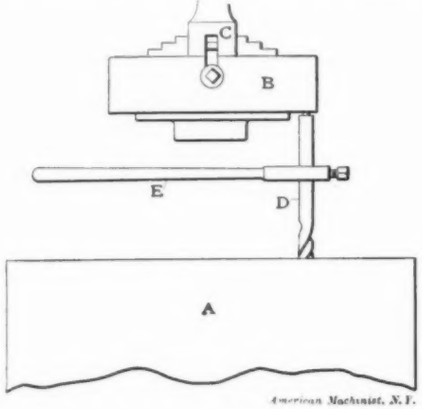
A curtain so arranged can be raised and lowered easily, will perfectly intercept the direct rays of the sun, will obscure but a small amount of the general light, and it also has the advantages of easy adjustment for hight, can be readily washed to keep clean and the first cost is very small It will always keep parallel and in place, even if the window be open, as it cannot be blown about by the wind, as the guard wires *B B* keep it in place.

I venture to say that this little device will be much appreciated by many a workman.

Buffalo, N. Y. HENRY BARNES.

Drilling Holes in a Casting Too Large for the Swing of the Drill Press

Having a large casting *A* with some holes so located on it that they could not be drilled by our upright drill we clamped



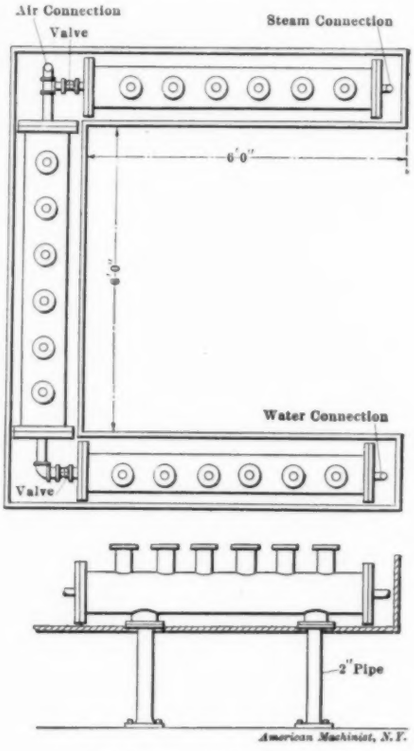
HOW THE HOLES WERE DRILLED

a four-jaw chuck *B* on the nose of the spindle *C*, a spot having been made near the edge of the chuck. The shank end of the drill *D* was turned so as to leave a small point in the center. A long-handled dog *E* was fastened to the drill. The chuck and work were moved around until the drill was upright on the desired place, the point on the top of the drill setting in the spot on the chuck. Two men turned the drill, while a third fed the spindle down. The holes were drilled quickly and easily.

Waltham, Mass. ARTHUR N. KING.

A Valve Testing Fixture

The illustration shows two views of a testing machine which I designed for testing valves, with air, steam, or water. The air pressure was at 125 pounds, steam at 90 pounds, water at either 40 pounds or 800 pounds. There was also a high-pressure connection for a hand pump with which we could test at 5000 pounds. The main object was to have it compact and still have enough room for one, two, or three men to work at the same time in testing valves. In testing with air the pressure is allowed to remain on longer than when testing with water. With this



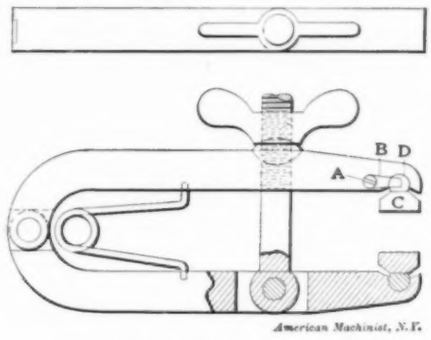
A VALVE-TESTING FIXTURE

plant one set of valves can be tested with water while other sets are being tested with either steam or air, the whole operation going on simultaneously, and each independent of the other. The testing pipes, to the flanges of which the valves to be tested are secured, are situated in wooden troughs, as shown. These troughs are covered on the inside with asphaltum, and their bottoms are pitched so that the water will run away readily, through the drain, which is not shown in the illustration. The testing pipes are also set low in the trough so as to avoid slopping the water all over the floor.

Germantown, Penn. D. A. W.

Toolmaker's Clamp

The sketch shows a toolmaker's clamp which I have found very satisfactory. In this sketch *A* is a 4x36 fillister-head screw



TOOLMAKER'S CLAMP

which, by the aid of flat spring *B*, holds the hardened jaws *C* in place. *D* is a piece of ¼-inch Stubs' steel, which is joined to the hardened jaw *C* by a small countersunk-head rivet. The special feature of this clamp is that the jaws conform to any taper and always have a full bearing on the work. The general arrangement of the pivoted arms, clamp nut, etc., is shown clearly and needs no explanation.

Kansas City, Kan. M. F. PARSONS.

Crossing the Fence to the Roll-top Desk

Everywhere you see the advertisements of the correspondence schools, and everywhere you see evidence of the good that they are doing. But there is one thing that they are doing that is hurting the machinist trade and themselves as well; that is, their window display, which shows a man poorly dressed standing at a lathe on one side of a fence and another seated at a roll-top desk on the other, with the placard questioning "Which side of the fence are you on?" In many of their advertisements this is the keynote of their appeal—the roll-top desk, the high salary goes with a boiled shirt, and the snap job in the office.

Our boys are too prone now to take the dressed-up jobs without holding out this mirage before them. True, many good-paying jobs allow their holders a desk and a white collar and cuffs, but too much hurry to get these symptoms of a fine position oftentimes does more injury than good. To the young man in the shop every legitimate encouragement should be given, but there is a larger field ahead of him, and right square ahead of him, than any he can find by any short-cut jump into the office.

"Men pay for being watched." This has been said so many times that the original author is lost to mind. Having to have someone watch you to see that you are working at all, or if you are doing things the right way, is an expensive luxury; but as human nature is made up it seems to be a necessity for most of us. Human nature having changed very little since Adam and Eve, it can reasonably be expected to stay about the same during the lifetime of the present generation. All this leads up to the statement that watching men is the best paid, most fascinating and exciting game that is paid for today. Many men do their watching from cosy chairs, but the road to the easy chair is not a direct cut through the medium of book learning.

PRACTICAL FORMS OF EDUCATION

We as a people are too much inclined to worship education; not that I think that too much learning is possible, but that what we usually mean by education is the memorizing of printed words. We realize too little that education of the hand to do things, of the eye to see what should be done, and of the tongue to say what to do, is of vastly more importance than the loading down of the brain with knowledge that may be useful under certain conditions that are uncertain of occurrence. The man who can intelligently direct the work of others must have done that work, or something very similar, himself. There have been many notable exceptions to this rule to prove it. While he must have done the work, the chances are rather against his being successful in directing the work if he has done his own work notably well. To do work well usually means minute attention to detail. The foreman who is too much bound up in detail gets the name of being "fussy," and seldom succeeds.

To see what needs to be done. Without this foresight no amount of skill, no amount of education is worth enough to pull a man over the fence. It is not taught in the schools, it never will be. To be sure the graduates of our technical schools usually have a greater amount of it than others, but that is only because of the process of elimination by which the graduates are selected. To see what should be done is very simple after someone else has seen it. The fact that some see and some do not is more to the discredit of those who do not than to the credit of those who do. The only training is to look, and a man can look for chances to see things just as well in one position as in another. Just imagine yourself in your employer's shoes. Ask yourself how you would look on various things and then see what your employer really does, and see if you can figure out how he really did look at it.

To tell others what to do means tact. Tact may mean the big stick in one case and taffy in another. It is likewise not taught by schools, though it is taught in school and likewise in shops. It is taught by fellow students and shopmates. A certain degree of sensitiveness makes a man receptive of the good effects of his neighbor's criticism. A greater sensitiveness cuts him off from the good effects just as effectually as a thick skin, simply because if you take the fun which the world pokes at you as jeers, you become toughened to it in time and only sit back and listen instead of falling in step for a forward march.

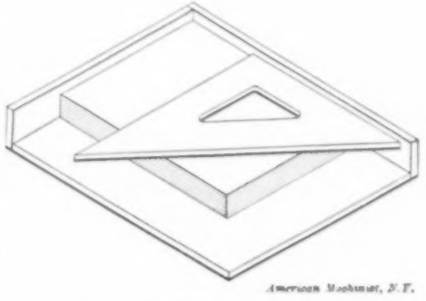
CARDINAL STEPS

Now with all these things, a knowledge of your trade, which you do not allow to become too petty in detail, a willingness and an ambition to see things to do, and a willingness to fight your battles with tact, what are the steps before you cross the fence to a roll-top desk? First, foremanship; second, the same; third, ditto. Then what? You get a desk, and if you are wise you use it to lay your hat on while you get busy seeing that things are going as they ought to be in the shop. There are men who run their shops by telephone, or by letter writing, but they are usually men who are in charge of the great industries, who have worked their way through the stages of personal supervision; and then again, they do see as much as is possible of their work carried out. To be sure, there are a few card-index fiends who only know their men by number or symbol, and who act on the general principle that if one man won't do what they want another will; but they are relatively few. Business is done today as it has been in the past, and as I believe it always will be, on a basis of goodwill and knowledge of human nature. No amount of book learning will make possible a short cut past the stages of study of fellowmen, desirable though it may be for other reasons.

Springfield, Mass. ENTROPY.

A Sketch Pad Holder

Inclosed is a sketch of a sketching-pad holder which I made from a large cigar



A HOLDER FOR A SKETCH PAD

box, and which I have used a long time, finding it very convenient and light for holding to sketch.

Syracuse, N. Y. B. F. ENNIS.

Discussion of the Previous Question

Letters from Our Readers Showing How Many Men of Many Minds Look upon Various Subjects Opened up in Previous Numbers

WE PAY FOR THESE ALSO

A Homemade Pneumatic Elevator

On page 430 Philip Bellows gives a clear description of a homemade pneumatic elevator, which an ingenious mechanic had designed and constructed for use in a tool storeroom. The description of the mechanism which constitutes the motive power for the elevator closes with: "After taking one's stand in the cage the cord is pulled, and you expect sudden death; but you become alarmed when you find nothing has happened, and you stand in fear of you know not what, for a space of about two seconds. You have just begun to think of giving the trigger a second tug, when up you go with an airy bound and your face is on a level with a floor above, a distance of some 14 feet. . . . ."

I would like to help him to surmount the difficulty which his elevator has in its propensity to "hesitate," and "bound airily." That kind of behavior in *any* machinery is bad; but in an elevator it is very bad. It surrounds one with a feeling of insecurity, which we can do very well without. Mr. Bellows' lift may be greatly improved.

In the tool stores over which I have control, there is a lift of a similar type to his, but differing from it by the absence of all that goes to make one expect "sudden death." The lift is under absolute and precise control and has a 16-foot lift; the stroke of the piston (which is 10 inches diameter) is 4 feet 6 inches. The air pressure is 100 pounds per square inch, and the 16-foot stroke is provided by means of a 4 to 1 "jigger gear," such as is used on hydraulic cranes of the Armstrong type.

Reluctance or hesitation in starting is provided against in the following way: Instead of using the "admission" system for exerting pressure on the piston the "exhaust" system is made use of. In explanation, it may be said, with the "exhaust" method, the air cylinder is always completely full of air at 100 pounds pressure; and, when it is required that the lift should be worked, it is necessary only for the air pressure to be exhausted from the opposing side of the piston, and having an amount of power provided which is superlatively ample for the purpose, the exhaust valve may be manipulated just the amount required to give the correct or desired speed of travel of the elevator. The system has been applied with success to the air cylinders of large filter presses, and also to an hydraulic steam-engine regulator.

JOSEPH T. TOWLSON.

Silvertown, England.

Steady Pins in Engine Cylinder Feet

On page 227 Stanley M. Mills discusses the merits of square versus round, steady pins for engine cylinder feet, and asks one or two questions on my article contributed on page 70.

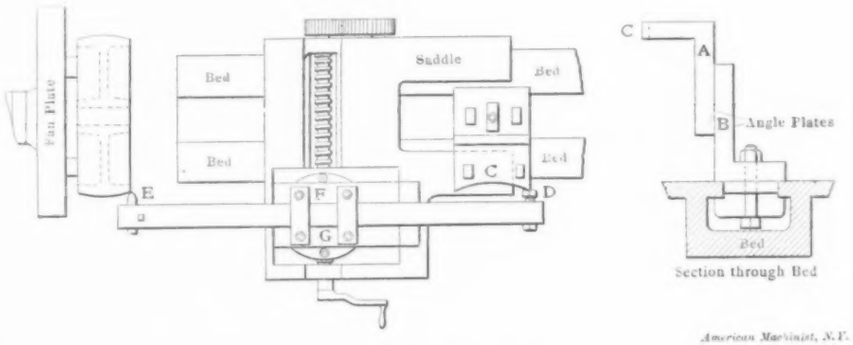
In reply to Mr. Mills' question as to whether we made any provision for the cross movement of the cylinders when we fitted square keys, by having a tongue planed on the bottom of the cylinder feet fitting into a groove in the bed, I would say we did not. The feet and head were planed perfectly flat. I quite appreciate what Mr. Mills says, that he would hate to fit square keys. I also used to hate to fit them. It is not a very desirable job by any means, as you have to drift the square hole (first drilled) the best way you can, and having a blind end, as shown on page 70, it is a very difficult job to get the key out when fitting it. The keys have to be forged with a hook head on so that you can drive them back with the hand hammer. They must also be long. When driving back they bend, which makes them more difficult to fit. The key when fitted is cut off the end, and another one forged and so on until the bar is used up to the head.

I also heartily appreciate what Mr. Mills says regarding the inspector who condemned the round stop pins. The fact is they have got to find some fault somewhere to hold their position and show their authority, and as nothing else could be found in this case he made a case out of the method of steadying the cylinder feet. We quite agreed that the keys had a much larger area to shear than the round pins, but the latter certainly provides against side play, whereas the square keys do not, and there is no doubt they are much more expensive to fit than round stop pins. We had been fitting these round pins for about 40 years and I have never yet come across one which has given the slightest trouble, so they are quite satisfactory under ordinary conditions. On the other hand, although we have not been fitting square keys long we have never had any trouble with them either.

Leeds, England. ENGINEER.

Crowning Pulleys

Having read the article on the "Crowning of Pulleys," by E. W. Harris, on page 393, it reminded me of the means I adopted for the same purpose while holding the position as working foreman at a general engineering shop in Leeds. The illustration will show the idea. I ran a lathe and kept my eye on the shop, and also did the marking off, so you can see it was necessary that I should have plenty of automatic feeds. There were boring and turning pulleys, etc., but when it came to crowning I had to devise an automatic feed. I got two of the ordinary shop angle plates, bolted *B* to the bed of the lathe, and after shaping out an arc *C* on the edge of *A* I bolted it to *B*. I then drilled a ½-inch tapping hob and fitted the screw *D*, rounded the head and put a lock nut on, placed boring bar in position by placing the tool *E* in the center of the pulley, and the screw *D* in the center of the angle plate. I then loosened nuts *F* and *G* just



CROWNING RIG FOR PULLEYS

sufficient to allow the tool rest to swivel and started the cut. The pressure against the tool kept the screw against the angle plate. I was enabled to rough and finish by this means and found that by keeping the tool loose central between the pulley and plate the arc was the same as that on the plate. If I wished for a smaller crown I had only to keep the tool rest closer to the pulley. I found this a very satisfactory and cheap rig, and one that could be easily fitted up. The tools used could be used for other purposes.

A. BROWNING.

Old Hill, England.

The attachment described by A. W. H., on page 393, was designed by me several years ago and is still in regular use. The lost motion was foreseen and overcome by cutting the nut on the feed screw in two and then by adjusting the two halves closer together or further apart, all lost motion was easily taken care of.

Leicester, England. W. D. ADNITT.

Solution of "A Pin Problem"

I offer the following remarks on the "Pin Problem" discussed on page 529: All the equations and calculations there given are correct as far as they go, and are satisfactory in cases to which they are applicable. But the trouble is, they are not entirely suitable to the case described relating to the pin. The equations given refer only to the bending moment in the pin and the deflection produced by this bending moment. In addition to these stresses there are other forces acting in the pin, chief of which are the horizontal and vertical shear. Speaking generally, the shear is of relatively little importance in long beams, but in short beams the shear tends to become of much greater importance, and this pin falls in the latter class.

Considering the deflection caused by the bending only of the pin, the formula given states correctly that the deflection varies as the cube of the length of the pin. This means that for a short pin the deflection is very short indeed, and as the length of the pin approaches zero, the amount of the deflection is a still smaller quantity. Hence, to keep the work done during deflection equal to a given constant amount, as the deflection approaches zero, the strength of the pin and, therefore, also the diameter of the pin must approach infinity. Therefore, the results obtained in the discussion previously referred to are perfectly consistent and reasonable in accordance with the assumptions made.

For this problem, however, a more satisfactory solution is to ignore entirely the deflection due to bending and to consider only the deflection due to shear. As before, let

W = Weight dropped on the pin,
h = The distance the weight drops,
D = The maximum deflection of the pin,
P = The load on the pin corresponding to this deflection,
d = The diameter of the pin,
a = The area of the pin,
I = The moment of inertia of the pin section,
F = The shearing modulus of elasticity,
f = The maximum fiber stress, and
l = The length of the overhung pin to the point of application of the load.

$$W h = \frac{D P}{2}.$$

$$D = \frac{P l}{a F}.$$

Since the pin is in more danger of breaking by bending than by shearing,

$$P = \frac{2 f I}{d l}.$$

Therefore,

$$W h = 50 = \frac{D P}{2} = \frac{P^2 l}{2 a F} = \frac{4 f^2 I^2 l}{2 a F d^2 l^2} = \frac{2 f^2 I^2}{a F d^2 l}.$$

Substituting the numerical values

$$f = 10{,}000,\ I = \frac{d^4}{20},\ a = \frac{\pi d^2}{4},\ F = 12{,}000{,}000,$$

$$l = \frac{9}{8},$$

we obtain,

$$50 = \frac{2 \times 100{,}000{,}000\ d^8 \times 4 \times 8}{\pi\ d^2 \times 12{,}000{,}000\ d^2 \times 400 \times 9},$$

$$d^4 = 1060,$$

$d = 5.7$ inches.

Then

$P = 166{,}000$ pounds,
$D = 0.0006$ inch.

Shearing stress per square inch =

$$\frac{P}{a} = 6500$$

pounds.

There would be a slight additional deflection due to the bending of the pin, but it would be insignificant in amount compared with the deflection due to the shear as computed above. There would also be some additional deflection due to the compression of the material adjacent to the point where the blow is received. This is still more difficult to calculate and perhaps no one has yet devised a theoretically satisfactory method of allowing for it. Probably in our case this last source of deflection is of considerable importance and hence the calculated size is larger than necessary. If the material of the pin or of the falling weight is battered by the blow or flows at all under the impact, it is equivalent in its effect to a corresponding increase in the amount of deflection. Hence a very small permanent yield of the material may serve to absorb a large portion of the energy of the impact.

This problem is an excellent illustration of the necessity of looking at a matter from every point of view and giving due weight to every consideration in order that the results obtained by calculation shall be sufficient and valid.

Iowa City, Iowa. S. M. WOODWARD.

The formulas as developed on page 529 are correct under the assumptions made. These assumptions are that the overhang pin is fastened rigidly on one end in a frame, and that this frame itself is so rigid as not to allow any deflection or distortion. This condition is seldom if ever met in practice. Another wrong assumption is that neither the falling body nor the pin is compressed under the influence of the load P. It is natural that under these conditions the diameter of the pin will figure by the given formula as infinite if the length of the pin is zero, because the deflection must be zero and according to formula (1)

$$W h = \frac{D P}{2}$$

P must be infinite if D is zero, and the diameter of the pin must also be infinite.

On the other hand, if the length of the pin is infinite, a very small value of P will produce an infinite deflection and if D = infinity in formula (1), P must be equal to zero, and the diameter of the pin will consequently also be zero.

In order to treat this problem in a practical manner, I would first determine the value of P, which is admissible to act through the pin on the frame, and then determine the diameter d by the strength formula

$$P l = \frac{d^3}{10} f,$$

or assume the diameter d and figure P by the same formula. Then determine from formula (1),

$$W h = \frac{D P}{2},$$

the value for D. After this, figure the actual deflections under the influence of P of the pin, caused by bending and compression of the pin and also by the deflection of the frame, and add to this the amount of compression in the falling body. If the sum of all these deflections is equal to or greater than the value D then the force P will be equal to or smaller than the value assumed and the construction will be safe. If the sum of all these deflections is smaller than the value D, then it is necessary to provide some artificial means to make up the difference. This can be done with a spring arranged either on the falling body or on the pin, which will deflect the necessary amount under the influence of the assumed force P.

Vorstadt, Germany. CARL MOMMA.

The formulas given in "A Pin Problem" seem to be correct. An approximation has been made, however, in formula (1) which to be theoretically correct should be

$$W(h + D) = \frac{D P}{2};$$

yet this will make no material difference in the result: Several assumptions have been made which will make the results differ from the actual facts. The formula

$$D = \frac{P l^3}{3 E I}$$

is an approximation founded on the supposition that the pin bends only very slightly. In deriving formula (1) it has been assumed that neither the weight nor the pin has been deformed by the blow, and that the frame of the machine is perfectly rigid. Part of the work no doubt would go into producing elastic deformation in the pin, weight and frame of the machine.

To discuss the formula let us put it in the form

$$d^3 f^2 l = Wh \times 30 \times E.$$

This formula shows that for any certain length of pin the stress will vary inversely as the diameter. The physical meaning being, if we make the pin large it will be very stiff. When the weight falls, therefore, and strikes the pin the deflection will be small and consequently P will be large. This would tend to make f large were it the only factor to be considered. But at the same time increasing the size of the pin tends to reduce f much more rapidly on account of the increasing area of the pin and the more effective manner in which the material is placed. The formula also shows that other things being equal, f will vary inversely as $\sqrt{l}$, and that for any certain stress d will also vary inversely as $\sqrt{l}$, or, as the article puts it, "if we were to reduce the length of the pin to zero, the fool formula says the diameter should be infinite."

If we use spring steel for the pin we might increase f to 60,000 pounds, then

$$d^3 = \frac{50 \times 1 \times 30 \times 30{,}000{,}000}{60{,}000 \times 60{,}000 \times 1.125} = \frac{450}{36 \times 1.125} = \frac{400}{36},$$

and, $d = 3.33$ inches; a seemingly more reasonable result. If we were to decide to take up the shock by means of a helical spring we would have the following formulas:

$$W h = \frac{D P}{2}$$

as before,

$$P = \frac{f I_p}{\frac{d}{2} \times R}, \text{ and } D = \frac{R f l}{\frac{d}{2} \times c}$$

where the letters are used for the same quantities as before and Ip is the polar moment of inertia, d = diameter of wire out of which the spring is made and R = radius of coil and c = transverse coefficient of elasticity. Then combining the equations above,

$$W h = \frac{f I_p}{\frac{d}{2} \times R} \times \frac{R f l}{\frac{d}{2} \times c} \times \tfrac{1}{2},$$

since $I_p = 0.1\ d^4$ this becomes

$$d^3 f^2 l = \frac{W h \times c}{2}.$$

Here, as in the formula for the pin, when l is fixed, d varies inversely as f and when f is fixed d varies as $\sqrt{l}$. Take $l = 1$ inch, $c = 10{,}000{,}000$, $f = 60{,}000$ then d = about ¼ inch. If we take l as 10 inches long, then d = about 0.08 inch. These results seem reasonable and yet if we reduce l to zero the "fool formula" will say that the pin must be infinite in diameter.

Stillwater, Okla. R. E. CHANDLER.

[Other valuable discussions of this problem have been received, but lack of space prevents our publishing them.—ED.]

More About Marking Tailstocks

Among the various discussions in your paper on the question of marking and graduating tailstocks of lathes, I have seen no mention of the method which is in use in the toolroom where I am employed of ascertaining when the tailstock has been returned to its proper position after having been moved. This is to simply file a flat, smooth place on the side of the tailstock, bringing the upper and lower parts flush with each other, this being done when the tailstock is in perfect alinement. It is necessary only to rub a finger over the flat surface to ascertain if the tailstock is properly set for straight work. This may seem a rather crude method to some, but I have proved to my satisfaction that I can tell when the two surfaces are in line within 0.0005 inch, especially if the corners are sharp. I believe this is closer than it would be possible to get by matching lines, which is a very common method.

To set the tailstock in line with the headstock before marking I prefer a test bar ground perfectly parallel and a good test indicator. If no test bar is at hand a bar of suitable length may be turned for a short distance on each end exactly the same size and used in the same manner, though a ground bar is to be preferred as it is more convenient. To get a good job there were quite a number of things to look to. The lathe ways must be perfectly clean and oiled; the centers clean and fit perfectly in the spindles; the centers in the test bar clean; the test bar properly adjusted between the centers with a drop of oil at each end; the tailstock spindle clamped about the same as it would be under working conditions. Then the indicator should be applied at the *headstock* end and the spindle revolved, the bar standing still. If the indicator registers any movement the head center runs out and should be made true, grinding it if necessary. Then the spindle should be allowed to stand still and the bar rotated; if the indicator registers movement in this case either the center is not clean, or the bar runs out. Then the indicator should be applied to the *tailstock* end of the bar and the bar rotated to prove the center is clean and the bar true.

Now apply the indicator to the headstock end of the bar and note the reading, move the carriage to the tailstock end without disturbing the adjustment of the indicator and adjust the tailstock until the same reading is obtained, making this adjustment with the tailstock clamped lightly to the lathe bed; then clamp the tailstock firmly and note if the reading of the indicator is affected. Traverse the carriage back and forth once or twice and if no movement of the indicator is registered it may be considered that the tailstock is in line and the flat surface on the side may be filed perfectly smooth to facilitate reobtaining this position should it become necessary to set the tailstock over for tapers, etc. If the lathe ways are badly worn it will be a difficult matter to set the tailstock so that the lathe will turn straight, and it would be advisable to use a test bar of a length similar to the work it is intended to do, and set the tailstock in line at this point, applying the indicator at a point the same hight as the lathe centers, using a tool with its cutting edge set at this point.

As to graduations on the tailstock to indicate the amount of set-over, I fail to see where they are of any use. Graduations on the spindle of the tailstock, however, are very convenient, and more so if there are the same number of parts to the inch as there are threads on the screw, and a dial is provided to read in thousandths.

Another very convenient addition to the tailstock of a lathe is a permanent hight gage of the same hight as the centers. A good way to do this is to mill out a portion of the spindle leaving a flat, level spot the same hight as the centers, of sufficient width and length to allow a man to place a scale or straight-edge on to ascertain that the cutting edge of the tool is at the proper hight in cutting threads, etc.

Albany, N. Y. T. COVEY.

The coinage executed by the mints of the United States during 1908 amounted to $197,238,377 in gold, of which $106,182,420 was in double eagles, and $4,829,060 in eagles of the design prepared by the American sculptor, the late Augustus Saint-Gaudens.

Some Tests of a New High Speed Steel

Novo Superior Steel in Turning and Drilling Tests, Working on Forged, Rolled, and Cast Steel and Cast Iron. Rules for Forging, Hardening, Etc.

EDITORIAL CORRESPONDENCE

The new steel, Novo Superior, which is made by Jonas & Colver, Ltd., of Sheffield, England, and sold by Hermann Boker & Co., New York and Chicago has been tested out in numerous places and is now placed on the market for sale. These tests enable us to give to our readers some data for which many are looking.

The character of the new steel is such that it will stand a very materially higher cutting speed than the older type of high-speed steels. The increase of this speed, of course, depends on the nature and character of the work. On soft material it has, in some instances, cut from 50 to 60 per cent. higher, and on very hard material an increase of 25 per cent. has been made. An increase of speed, however, is not always advisable.

Harder Materials Cut and Cutting Edge Wears Longer

It will cut harder materials than the ordinary high-speed steels. An instance of this was some guide blocks which had been hardened on their face and very much stiffened at the dovetail parts. These parts had to be planed into shape again owing to their warping. High-speed steels, when tried on this, turned over on the cutting edge, whereas the new steel planed the work successfully. Cast-iron rolls which had been chilled in casting until they were too hard for the ordinary high-speed steels to cut, were turned with the new steel at a speed of 80 feet per minute, a depth of cut 5/16 inch, and a feed of 1/8 inch.

The new steel also holds its cutting edge much longer than the ordinary high-speed steel, tests which have been conducted showing that the ordinary steels have to be ground from four to eight times for every once that the new steel is ground. In some of the tests this difference has shown up as high as 12 to 1. In one test which was carried on with milling cutters, that were milling annealed high-speed steel, the new steel was ground only once as against six times for another high-speed steel. On lathe, planer and shaper tools the same average of 6 to 1 holds good.

What Mr. Winder Says

B. W. Winder, the superintendent for Jonas & Colver, Ltd., who produced this steel for them, came to this country to carry on the tests before introducing the steel, and he says: "It must be borne in mind that this steel was not introduced to cut at a very much higher speed and heavier cuts than the present ordinary high-speed steels, as this would necessitate radical alterations of plants. It is rather intended to place in engineers' hands a steel that will last very much longer than the present brands. In many cases it has enabled the user to work up hard castings that previously had to be annealed before they could be handled on the machine. And further, the steel may be hardened in water without fear of cracking, which is a most important factor in shops where oil or cold blast are unavailable."

"The advantages to be derived from a steel of this description having such prolonged lasting powers is manifest particularly in automatic machines where the great cost is the skilled labor that is required to fix up the machine."

Mr. Winder also expressed his appreciation of the courtesy shown him by the large manufacturers here, who unreservedly placed at his disposal the services of their best workmen and the use of their magnificent machinery for conducting the tests.

Forging, Hardening and Grinding

The instructions given for working and treating the steel are that in forging it should be heated carefully without blast in the slow part of the fire, until it has reached a dull-red heat. After this the blast may be used and the steel brought more quickly up to the forging heat, which should be a full yellow. In no case should it be forged after the heat has dropped below a light red. After forging the tool should be allowed to cool slowly on the floor of the shop.

Before heat-treating the tool it should be rough-ground. After this it should be slowly and carefully heated until it shows a good red color, then it can be heated more quickly until it has been brought up to a full white heat; that is, until the extreme edge of the tool begins to turn over or show signs of melting. Then it should be quenched in water, brine, paraffin, or oil at a normal temperature of from 55 to 60 degrees Fahrenheit, according to the degree of hardness required. Where intense hardness is desired brine will be found to give excellent results. Should the tool not be as hard as required, a second hardening will often prove beneficial. When hardening in water it is necessary to keep the tools moving in order to prevent cracking.

In grinding it is most essential that the tools should be ground very lightly on a wet soft sandstone. If no sandstone is available an emery wheel may be used, but only when a plentiful supply of water is running on the tool.

Quenching Bath.	Speed in Feet per Minute.	Feed per Inch.	Depth of Cut in Inches.	Length of Cut in Inches.	Condition of Tool.
Water	102	35	1/32	1/2	Ruined.
Sulphuric acid	102	35	1/32	1 1/2	Ruined.
Paraffin	102	35	1/32	1 1/2	Ruined.
Paraffin and salt	102	35	1/32	6 1/2	Ruined.
Brine	102	35	1/32	12	Good.

HARDENING TEST OF NOVO SUPERIOR STEEL.

Times Hardened	1	2	3	4	5	6 to 10
Degrees Fahrenheit when hardened	1877	2048	2030	2021	2034	2039 to 2057

	Original Size.	Alterations.				
Diameter	2.999	3.000	2.994 2.999 3.011	2.996 2.994 3.009	3.000 2.993 3.006	3.004 2.992 3.002	3.019 2.991 3.013—3.021
Thickness	1.003	1.002 1.001	....	1.000 0.998	0.996 0.997	0.995 0.993	0.984—0.988 0.973—0.982
Hole	1.003	1.006	1.005 1.012	1.011 1.009	1.011 1.011	1.013 1.013	1.027 1.031

The ring cracked along one end after the fifth hardening.
Size of Test Sample: Ring 3 inches diameter, 1 inch thick, with 1 inch diameter hole.
Method of Hardening: In bare crucible, in Novo hardening furnace.
Hardening Medium: Water, at a temperature of 65 to 75 degrees Fahrenheit.

EXPANSION AND CONTRACTION EXPERIMENTS ON NOVO SUPERIOR STEEL.

Turning 2.00 Per Cent. Carbon Steel

In some tests which were carried on in Germany the hardening was done by heating the steel very slowly to a dark red, and letting it lie several minutes in the fire at this heat so that it would soak entirely through the piece. Then the tool was brought up to almost the melting point and quenched. This melting point, by the way, in the new steel is about 10 per cent. higher than in the ordinary high-speed steel. The steel should be allowed to soak in the heat until it has reached a bright red before starting the blast.

In these German tests, after hardening the steel as above stated, it was put to work on a very strong lathe to turn a Siemens-Martin 2.00 per cent. carbon steel. This is a metal which is unusually hard and seldom used. Therefore, it gives a condition which will not be met in ordinary practice. The Novo Superior steel, however, took a 3/8-inch deep cut on this, at a feed 1/16 inch, and a speed of 36 feet per minute. While running at this feed and speed it cut 4¾ inches along the length of the bar. The speed was then raised to 50 feet per minute with the same feed and depth of cut, and 1¾ inches was turned along the length of the bar. The tool used was 1¼ inches square and was hardened in water.

Turning 0.70 Per Cent. Carbon Steel

On another test which was made on 0.70-per cent. carbon steel of the same make, a tool 1¼ inches square hardened in water was used. It was run at the rate of 48 feet per minute, while cutting a chip ¼ inch deep, with a 1/16-inch feed, and it turned 13 inches off the length of the bar without falling down. The speed was then increased to 65 feet per minute, and the tool cut 1⅛ inches farther before failing. Another cutter was then taken which had been hardened in oil, and under the speed of 48 feet per minute, with the same depth of cut and feed, the tool cut 13 inches without falling down, and when the speed was raised to 65 feet per minute it cut 2 inches farther.

Various steels were then tried at the same place in order to get a comparison of the work the different steels would do. These were all tried under the same conditions, namely, a speed of 65 feet per minute, a depth of cut of 3/16 inch, and a feed of 1/16 inch. The material which was cut was a 0.70-per cent. Siemens-Martin carbon steel, and the results were as follows:

Novo Superior, hardened in water, turned 4⅛ inches lengthwise of the bar. Novo Superior, hardened in water and oil, turned 3¾ inches. Another Novo Superior, hardened in water and oil, turned 4⅜ inches. Novo Superior, oil hardened, turned 8⅞ inches, and other steels as follows: Novo steel, air hardened, 2⅛ inches; another Novo steel, air hardened, 3 inches; a noted Austrian steel, 2½ inches; a noted Belgian steel, 2 inches; a prominent German steel, ⅜ inch; another German brand, 1 inch; a third German steel, 1½ inches.

Tests Made by Daimler Motor Company

Some experimental tests were made at the works of the Daimler Motor Company, Ltd., Coventry, England, which show the expansion and contraction, the effect of different quenching baths and the cutting quality of the steel as given in the accompanying tables.

Kind of Steel.	Material Cut.	Speed in Feet per Minute.	Feed per Inch.	Denth of Cut.	Length of Cut, Inches.	Condition of Tool.
A. An Austrian high speed	nickel steel	200	38	1/16	3½	Ruined.
B. Novo special	nickel steel	200	38	1/16	½	Ruined.
C. Novo	nickel steel	200	38	1/16	0	Ruined.
D. Ordinary high speed	nickel steel	200	38	1/16	0	Ruined.
E. Ordinary high speed	nickel steel	200	38	1/16	0	Ruined.
F. Ordinary high speed	nickel steel	200	38	1/16	0	Ruined.
G. Novo superior	nickel steel	200	38	1/16	12	Good.

First Cutting Test.

Kind of Steel.	Material Cut.	Speed in Feet per Minute.	Feed per Inch.	Depth of Cut.	Length of Cut, Inches.	Condition of Tool.
A.	nickel steel	126	38	¼	5	Good.
B.	nickel steel	126	38	¼	5	Ruined.
C.	nickel steel	126	38	¼	2	Ruined.
D.	nickel steel	126	38	¼	2	Ruined.
E.	nickel steel	126	38	¼	1¼	Ruined.
F.	nickel steel	126	38	¼	0	Ruined.
G.	nickel steel	126	38	¼	12	Good.

Second Cutting Test.

Kind of Steel.	Material Cut.	Speed in Feet per Minute.	Feed per Inch.	Depth of Cut.	Remarks.
Novo superior	cast steel naves	38	38	¼	3 naves turned with one grinding.
Novo	cast steel naves	29	38	1/16	Reground once, 2 cuts for each nave.

Third Cutting Test.

Kind of Steel.	Material Cut.	Speed in Feet per Minute.	Feed.	Depth of Cut.	Remarks.
Novo superior	cast iron sleeves	107	by hand	¼	Tool reground after turning 12 sleeves.
Novo	cast iron sleeves	107	by hand	¼	Tool reground after turning 4 sleeves.

Fourth Cutting Test.

Kind of Steel.	Material Cut.	Speed in Feet per Minute.	Feed per Inch.	Depth of Cut.	Remarks.
Novo superior	nickel crankshafts	50	35	¼	Tool reground after rough and finish turning 6 ends, each 8 inches long.
Novo	nickel crankshafts	50	40	¼	Tool reground after roughing out 1 end.

Fifth Cutting Test.

TABLE OF TESTS MADE BY THE DAIMLER MOTOR CO., LTD., COVENTRY, ENG.

Turning 0.40 Per Cent. Carbon Steel

In some tests which were carried on at the shop of Ransomes, Simms & Jefferies, Ltd., Ipswich, England, a Novo Superior tool ⅞ inch square was used to turn a 0.40-per cent. carbon-steel shaft 4 inches in diameter.

In the first test the speed was 65 feet per minute, the number of revolutions 62 per minute, the depth of cut ⅛ inch, and the feed 1/16 inch. The tool turned 2 feet 4 inches lengthwise of the bar, and at the end of the cut was in good condition.

For the second test the same tool, depth of cut and feed were used, but the speed was increased to 98 feet per minute. On this test the tool also turned 2 feet 4 inches lengthwise of the bar, and the condition of the tool was still untouched.

For the third test the same tool and depth of cut were used, but the feed was changed to 1/32 inch and the speed increased to 120 feet per minute. In this test 2 feet 4 inches was also turned lengthwise of the bar, and the condition of the tool at the end of the cut was good.

The fourth test was given with the same tool, the same depth of cut and feed as in the third test, but the speed was increased to 160 feet per minute. This gave a rate of traverse along the length of the bar of 2⅜ inches per minute, and the tool cut 1 foot 10 inches lengthwise of the

bar. At the end of this test the tool was giving way, owing to the bar being very seamy and full of sand.

Turning Cast Iron

Another test was in turning a cast-iron flywheel 5 feet in diameter, with a tool ⅞ inch square. The speed was 56 feet per minute, depth of cut ⅛ to 3/16 inch, and the feed 1/10 inch. The width of the face turned was 4½ inches, and the condition of the tool at the end of the cut was good.

In a test made by A. Ransom & Co., Ltd., Newark, England, a tool 1¼ inches square was used to turn up a cast-iron pulley wheel 5 feet in diameter and 6 inches face. The speed was 107 feet per minute, the depth of cut 5/16 inch, and the feed per revolution 1/32 inch. After turning up the entire face of 6 inches the tool was taken out in good condition. With other brands of high-speed steel the maximum speed which they were able to obtain was from 50 to 55 feet per minute, as the tools gave way quickly when this speed was exceeded.

In a test which was carried out by Marshall Sons & Co., Ltd., England, a tool 1½ inches was used to turn a cast-iron flywheel 5 feet 1 inch in diameter and 8 inches face. The speed was 55 feet per minute, the depth of cut ⅛ inch and the feed ⅛ inch. The tool faced up the whole of this wheel, which was 8 inches across and was still cutting well when taken out.

Another test by this same firm was with a tool 1¼ inches square, which was turning a 0.40-per cent. carbon-steel shaft that was 5⅜ inches in diameter and 4 feet 6 inches long. The speed was 90 feet per minute, the depth of cut ⅛ inch and the feed 1/10 inch. After traversing the whole length of this bar the tool was taken out and found to be untouched.

Turning Steel Forgings

Some tests which have just been made in this country by the Driggs-Seabury Ordinance Corporation, Sharon, Penn., are very interesting.

In the first test a Novo Superior tool 1x2 inches, hardened in water, was used to turn a piston rod for a steam hammer that was hand-forged and very tough. It was 9¾ inches in diameter and 20 feet long. This was a severe test on the tool as the shaft was out of round and the tool was cutting on one-half of the shaft only and was merely scratching the scale on the other half of its diameter. Seventy-two inches were traversed along the length of the piston rod, with a speed of 64 feet per minute, a cut ⅜ inch deep and a feed of ⅛ inch.

A second cut was taken from the same rod, which was then 8⅞ inches in diameter and round, at a surface speed of 40½ feet per minute. The depth of cut was ¼ inch and the feed ⅛ inch. In this cut the tool traveled 72½ inches along the length of the rod, and the condition of it at the end of the cut was perfect.

The same tool was then used without regrinding to reduce the collar on the rod from 9¼ to 8¼ inches, which made a depth of cut of ½ inch. It then turned 10 inches more, which made a total run of 82½ feet, and the tool was in good condition when it was taken out to make some comparative tests.

One of the well-known American high-speed steels was then put in to turn the rod on the 8⅞-inch diameter, with all the other conditions the same as when testing the Novo Superior steel. This tool traversed only 13 inches along the length of the rod before it fell down.

This tool was then replaced with a prominent English make of high-speed steel, and that fell down under the same conditions after it had traversed 15 inches of the length of the rod. As this completed the roughing cut of the rod no further tests could be made.

Turning Nickel-steel Forgings

Another series of tests was then conducted on rough-forged 3½-per cent. nickel-steel piston pins, which contained 0.40 per cent. carbon and were not annealed. These pins were hard and tough with lots of grit. The average diameter of the work was 3½ inches, the speed 52 feet per minute, the depth of cut ½ inch and the feed 0.072 inch per revolution. The first tool used was 1x2 inches and hardened in oil, with the temper not drawn. This Novo Superior tool cut 124½ inches before it needed grinding.

Another Novo Superior steel tool was then tried that was ⅝x1¼ inches and hardened in water with the temper drawn. This tool cut 78 inches and was then broken owing to its being caught in the work when starting the machine. Consequently, the steel was considered too light for this purpose, and this size tool was not continued with.

The next tool used was a Novo Superior steel 1x2 inches that was hardened in water, with the temper not drawn. This tool cut 80 inches and was taken out with the edge in as good condition as when it started. It was taken out in order to try out other steels under the same conditions. The next steel tried was a regular Novo steel tool ¾x1½ inches and this cut 45½ inches before the tool went down. A prominent American make of high-speed steel was then tried in a tool that was 1x2 inches and it ran 21½ inches before it broke down. A different grade of steel by the same maker was then tried, which ran only 8 inches and fell down. On the second grinding a run of 9 inches was obtained before it fell down, and the third grinding gave a run of only 5 inches. Another American make of steel was then used in a tool 1x2 inches, and this ran 27½ inches before it went out of commission.

On all of the above tests made by Driggs-Seabury Ordinance Corporation, the cutting edge of the tool was red hot while working and most of the time the tools were striking fire.

Drilling Cast Iron and Mild Steel

Two drilling tests which were made with the Novo Superior steel showed the wearing qualities in the cutting edge of the new steels to good advantage.

The first test was made on a close grained cast iron with a ¾-inch drill under the following conditions: Revolutions per minute, 466; depth of holes, 3 inches; speed per minute, 8½ inches; feed per revolution, 0.018; speed in feet, 92½ inches. In each case the drills were worked until dulled. Novo Superior drilled 70 holes, 3 inches deep, which equals 210 inches. The best of the ordinary high-speed steels drilled only 13 holes, 3 inches deep, which equals 39 inches.

This shows a wearing quality in favor of the new steel of between 5 and 6 to 1.

The second drilling test was made with a ¾-inch drill while drilling mild steel containing 0.25-per cent. of carbon, under the following conditions: Revolutions per minute, 247; depth of holes, 2¾ inches; speed in feet, 48½ inches; feed per revolution, 0.011 inch. Novo Superior drilled 60 holes, 2¾ inches deep, which equals 165 inches. The cutting edge was only slightly gone. The best of the ordinary high-speed steels drilled nine holes 2¾ inches deep, which equals 24¾ inches, and the cutting edge was ruined. This shows a wearing quality in favor of the new steels of between 6 and 7 to 1.

Miscellaneous Tests

Milling cutters working on high-speed steels spiral drilled, at considerably increased speeds, did four times as much work as ordinary high-speed milling cutters, before requiring sharpening.

On turning up nickel-steel shafts at 136 feet per minute, the new steels did 12 shafts as against five by the best tool of the ordinary high-speed steels, and the new steel was still untouched. Raising the speed to 200 feet per minute, it did 12 shafts against three, and was still untouched, while the other tools were completely used up.

On nickel-chrome crank shafts, which were exceptionally hard, it did 12 times as much as the ordinary high-speed steels which were being used.

In some tests which were carried on by the Interborough Rapid Transit Company at their One Hundred and Forty-eighth street shop in New York, some hard-steel castings 22 inches in diameter and 6-inch face were turned with a tool 1¼ inches square. These castings contained many blow holes filled with vitrified sand, but the new steel cut over the 6-inch face without any signs of wear at a speed of 50 feet per minute, a depth of cut of ½ inch, and a feed of 1/12 inch.

On some cast-iron water T's 20 inches

in diameter, a tool ½x1 inch took the cut without any sign of wear at a speed of 110 feet per minute, a depth of cut ¼ inch and a feed of 3/32 inch. Two other well known steels burned down and failed to cut this material at 88 feet per minute.

On some steel armature shafts that contained 0.45 per cent. carbon, and had a diameter of 4½ inches and a length of 4 feet 6 inches, the new steels took the cut without any sign of wear at a speed of 116 feet per minute, a depth of cut of ⅛ inch (as no more stock was to be removed), and a feed of 1/16 inch. The same tool was then used to finish these shafts, without regrinding, at a speed of 192 feet per minute.

Some remarkable results as regards speed were also obtained at this place. On some 0.40-per cent. carbon-steel axles, the lathe was stalled on the roughing cut while running at a speed of 151 feet per minute, with a depth of cut of 3/16 inch and a feed of ⅛ inch and the cutting edge of the tool was not harmed. On the finishing cut on some journals the speed was run up to 238 feet per minute without showing any sign of wear on the tool.

Equipment for Rebabbitting Armature Bearings

By F. H. Fullerton

One of the steady jobs in a street-car repair shop is the rebabbitting of armature bearings, and where there are a large number of cars to supply, the whole time of a number of men is required to keep these bearings in good shape. They are either in the form of half shells or solid, as at the right in Fig. 3. They are of a number of different types, but all of this general appearance with large openings in the sides to allow the felt oil pads or waste to come in contact with the journals.

FIG. 1. THE MELTING POT

The brasses are bored so as to leave room for about 1/16 inch of babbitt between the brass and the armature shaft, so that in case the bearing should heat sufficiently to melt the babbitt, the armature sinking 1/16 inch would still be kept from rubbing on the pole pieces of the field magnets and doing damage to the wiring. It would seem that since the shells are lined with babbitt they might be made of iron, saving the extra cost of brass. This is sometimes done, but in the event of the babbitt melting out the iron is very apt to cut the shaft badly, and a ruined armature shaft means the loss of the winding in most types of motor.

These shells are first well tinned on the inside, then a brass plug, which fits the oil opening, is clamped on and the bearing babbitted over a mandrel which leaves the bore about ¼ inch smaller than the required size. They are then trimmed up with a chisel and the babbitt bored out to standard sizes.

I once had the job of reconstructing the equipment for this work in a place where it was being done in a very crude way, and since two men did nearly double the work that three formerly did, I venture to describe the layout.

Fig. 1 shows the melting outfit. One of the American Gas Furnace Company's melting pots was fitted with a cast-iron table top. The flange around the hole in the table turns down and rests on the edge of the pot; the back edge has two lugs on the under side by which it is secured to the wall.

Just back of the pot is a tray-shaped casting having its back edge extended upward to form a shield, and a spout or lip in front which delivers into the pot. The lower part of this saucer is lined with fireclay and has three ribs which the bearing rests on.

Centrally over this and at the proper hight is a gas burner of the blow-torch type, which throws its blast down into the bearing and melts out the old babbitt, the metal running into the pot. By this means the bearings are cleaned without wasting any more heat on the brass than is necessary, it being applied directly to the babbitt, besides the metal in the pot is not cooled as it is when the whole shell is dipped. After the babbitt has run out the hot shell is placed on supports (provided for it on the left-hand corner of the table) and tinned well on the inside if it needs it. Usually the tinning is all right, and needs only wiping out.

The bearing is then ready to be cast on the rig shown in Figs. 2 and 5. *A* is a cast-iron cylinder about 28 inches long by 5¾ inches bore. *B* is a base which is bolted to *A*. *C* is a hollow piston. *D* is a space inclosed by rings at each end of *C*. *E* is a retaining ring screwed into *A* and is to keep the piston from coming out at the top and also to hold the bearing. *F* is a hardened-steel hammer working smoothly in *C*.

The piston is made of seamless-steel tube with rings shrunk on each end and grooved for packing rings as shown. Into the ends of *C* are screwed steel plugs; the lower one, which is made of tool steel and hardened, has a ¾-inch hole drilled through it to admit air under the hammer *F*. The upper one is bored and threaded to fit the stub on the mandrel shown to the left in Fig. 3. This mandrel is tapered slightly for ease in drawing from the babbitt. At the top of the piston are drilled four ⅜-inch holes *G*. These allow air to pass from the space *D* into the piston above the hammer. *H* is a ¾-inch three-way cock altered, as

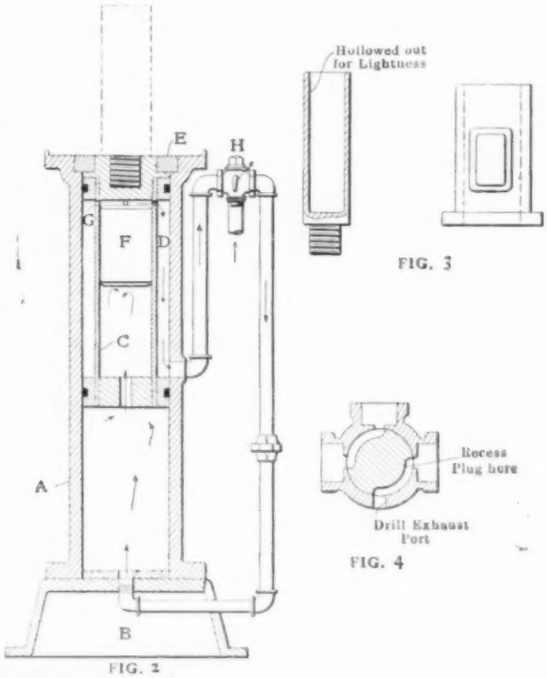


FIG. 2

FIG. 3

FIG. 4

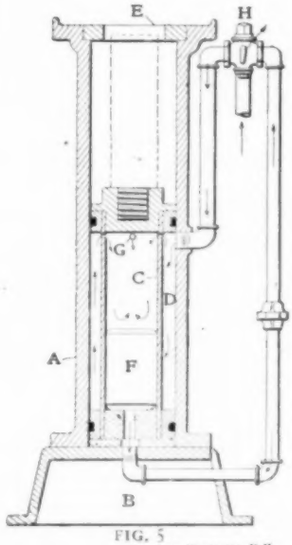


FIG. 5

THE BEARING, MANDREL AND CASTING RIG

shown by the section in Fig. 4, making a valve by which the air may be admitted above or below the hammer exhausting at the same time from the opposite side. Fig. 5 shows the piston at the bottom of the cylinder after the mandrel has been withdrawn from the bearing, the dotted lines showing the position of the mandrel.

The action is this: With the parts in position, shown in Fig. 2, with air pressure under the hammer and piston, the proper mandrel is screwed in place in the piston head after being warmed. A bearing is put on and cast, then upon throwing the valve quickly to the other position the exhaust port for the lower part of the cylinder is opened and air admitted to the space *D* and over the hammer through the holes *G*, driving the hammer against the bottom of the piston. This blow breaks the mandrel loose from the babbitt and the piston carrying the mandrel falls of its own weight to the bottom of the cylinder where a leather bumper breaks the fall. The bearing, resting on ring *E*, is then removed, another put in its place, the piston raised and the operation repeated.

As will be seen from Figs. 2 and 5 the space *D* is always in communication with its supply pipe and the hammer rises before the piston moves, being lighter, hence a blow may be struck with the piston in any position. When the hammer is at the bottom of the piston no more air is taken through the space *D* and there is no pressure forcing the piston to the bottom of the cylinder, gravitation alone acting on it.

A stop must be put on the valve so that the inlet port for the lower part of the cylinder can be opened only a very little, otherwise the piston would rise with sufficient force to break out the ring *E*.

After babbitting, the shells are taken to the boring machine. In this case a horizontal machine was used because it had to be, not because it was best adapted to the job. A vertical machine with a universal chuck would be best because the borings can drop clear of the tool down through the bearing into a receptacle under the table of the machine. Fig. 6 shows the tool used. A cutting tool goes first, cutting about 0.008 inch undersize, followed by a set of rollers bringing the bore to the required size and giving a fine burnished surface; this rolling also makes the babbitt more dense.

A is the bar made of mild steel with a shank to fit the machine. *B* is the roller path of hardened-tool steel bored to fit the taper seat on the bar back of the cutting tool. *C C* are the rollers ½ inch long cut from ¼-inch drill rod, hardened and with their corners slightly rounded. *D D* is the spacing or retaining ring which keeps the rollers in place; this ring is 1/32 inch thinner than the diameter of the rollers and ¾ inch wide; it has ¼-inch holes drilled in one edge just deep enough for the rollers; the drill cuts through the metal on both sides allowing the rollers to bear on the path on the inside and the babbitt outside. This ring is loose and moves around the path with the rollers. An end view of one roller and part of the ring is shown at *X*. *E* is a hardened-

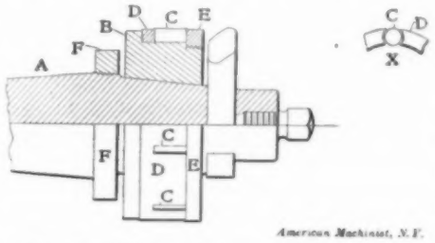


FIG. 6. THE BORING AND ROLLING HEAD

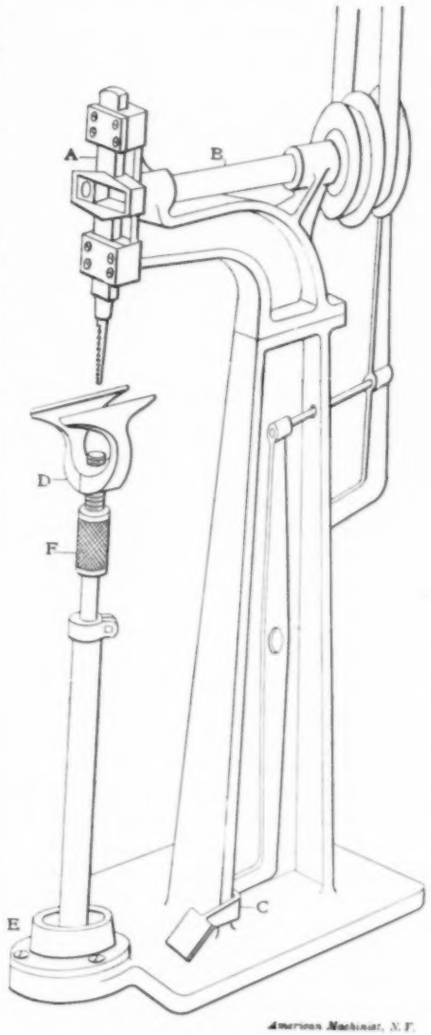


FIG. 7. THE SAWING MACHINE

steel ring screwed on the path *B* and serves to hold the parts together and to keep chips from getting under the rollers and also to set the tool by, it being the same diameter that the tool should cut. *F* is a ring threaded on *A* and turned with a spanner wrench and is used to force the set off when another size is required.

Each set of rollers will, of course, roll only one size so they were made in all the standard sizes required, ranging from 2½ to 3½ inches by sixteenths and all fitting on the same bar *A*. The sizes below 3 inches had seven rollers in a set and those above had nine.

The first cost of this outfit was a little high, but as it saves all calipering, does better work faster and is in constant use, it pays.

After the bearing is finished inside there still remains a thickness of ⅛ inch of babbitt closing the oil opening. The brass plug with which this opening is closed when babbitting is arranged to leave this much metal there so that there shall be no open holes for chips to collect in and get under the rollers. This must now be cut out. By the old method this used to be chipped out, often tearing the babbitt loose from the brass around the edges of the hole.

Fig. 7 shows the sawing machine with which it is now done. *A* is the saw bar having a vertical stroke of 2 inches, receiving its motion through a Scotch yoke, and crank pin on the end of the shaft *B*, which is started or stopped at will by pressing or releasing the foot lever *C* operating a friction cone and pulley on the end of *B*, the pulley running continuously and the cone fixed to the shaft.

The vise at *D* is on the upper end of a column that swings on a ball-and-socket joint at *E*. The ball is made of steel and has babbitt cast around it in the socket. This allows the vise to move in any direction and the joint can be tightened with the screws at the base. There is also a swivel movement in the grip *F* so that the screw may be turned without moving the lower part of the column and so the bearing can be turned in any direction. Between the grip and the ball joint is a telescoping portion for adjusting the hight of the vise. To clamp the bearing it is slipped under the fixed jaws of the vise between which it cannot pass, and the screw tightened up against it.

The saws for this machine were made from ¼-inch round spring steel, the blade part being flattened down to a triangular section ⅛ inch on the thickest edge, where the teeth were cut with a file; this enabled the operator to cut around a fairly sharp corner.

The hardware babbitt metals are found in four grades, viz., Nos. 1, 2, 3 and 4. They are made from a stock metal, usually hard lead (antimonial lead). This stock metal is sold as No. 4 metal. Tin is added to the stock metal to make the other three grades. No. 1 contains about 20 per cent. tin, No. 2 about 12 per cent., and No. 3 about 5 per cent. The ordinary composition of No. 4, or hard lead, is, lead, 77 per cent.; antimony, 20 per cent.; copper, 1 per cent.; arsenic, 1 per cent.; tin, 1 per cent.

An Extreme View of the Need of Industrial Education *

By P. Kreuzpointner†

I take pleasure in answering your query of November 10, whether the United States is likely to lose its industrial standing because of our unpreparedness for training those who are to enter industrial life.

Being a product of Germany's, respectively Munich's industrial schools, as they existed fifty years ago, when I was an apprentice from 1856 to 1861, and having followed the development of European systems of industrial education ever since, knowing the intense pressure of their economic conditions, knowing, as a member of two European technical societies, the drift of their industries approximately well, I answer your question in the words of prominent foreign engineers who visited this country, studied its industrial conditions, and gave me their personal opinions in conversation here in Altoona. The consensus of their opinion seems to be that, unless we adopt a system of thoroughly training our industrial workers in a manner similar to their own, this country cannot keep up its present industrial pace for more than twenty years because the education of the mass of the people—necessary to meet the ever tightening economic conditions, due to increase in density of population and decrease in quality, or quantity, of our resources, or both—is inadequate and inefficient.

In 1904, the German government sent a commission of six picked educators to study our educational facilities. They went about very quietly, they avoided dinners, publicity, brass bands, but with German thoroughness investigated and reported that it will be many years before our industrial education will approach the effectiveness of theirs, if ever.

In 1903, the superintendent of industrial education of the empire of Austria had some correspondence with me and among other things asked me my opinion as to the probable fate of Austria's small industries, which are the mainstay of that country because of lack of resources to support extensive concentrated manufacturing, these small industries being hard pressed by the flooding of Austria's cities with American goods. I told him that if Austria could keep its small industries above water for twenty years, they would not be much troubled by American competition for two reasons: First, that so little attention was paid in this country to technical education in our schools, that when this necessity for technical and scientific training is grasped and attempted, the psychological condition of the present growing generation will be too far advanced. It will not be receptive for philosophical thinking. The mind of present and past generations will have run exclusively along mechanical lines and mathematics in the higher branches, and along lines of manual dexterity in our manual training and trade schools. Thus a new generation will have to be made receptive, psychologically, to absorb and develop, upon a national scale, the mental power of readily grasping the depth and breadth of technical education, such as we need to bring us approximately to the standard of industrial education of our foremost foreign competitors.

Second, because of the absence of this technical training and the wasteful habits of the people and its workmen, habits which are the inheritance of a time when the people believed and many still believe, that our resources are inexhaustible and hence could be wasted with impunity; when saving was a badge of meanness and niggardliness. These wasteful habits and lack of technical knowledge necessary to make the best use of our remaining resources, cause them to diminish so rapidly that the next generation will have to exercise economy to keep enough for the growing home population, and little will be left to throw the products of our industries upon the markets of our competitors in competition with their home industries.

And even if we could instill into the people, within one year, the desire for technical education and the receptiveness of the mind of the masses to absorb technical teaching and knowledge and, with our usual energy, apply the knowledge, we would still be at a great disadvantage because our foreign competitors are used to pinched conditions and, if necessary, can tighten their belts still more, while our mechanics do not know as yet what a tight belt means, much less are they in a willing condition to tighten it a notch or two.

I have spoken with mechanics who told me that they would cause a revolution if they could not have two kinds of pie in their dinner pails. While this is easier said than done, nevertheless it indicates the spirit which, when our economic pressure becomes more severe, will increase our disadvantage when competing with people and mechanics of foreign countries, millions of whom think it a treat to have pie at Christmas and Easter and feast days, or think they are well off if they have a scrap of meat once a week.

At the annual meeting of the Eastern Manual Training Association, in 1902, I was amused when an enthusiastic domestic-science teacher, in a well prepared and creditable paper, detailed the economic value of this, that, and the other prepared dishes, and the blessings thus conveyed by the domestic-science department of a manual training school into the homes of the American mechanic. I was mean enough to spoil the pleasant illusion by calling attention to the fact that the American mechanic would consider such a diet good enough for the "Dago," the "Dutchman," the "Slovac," but not for him who considers brown bread a badge of poverty and would ostracize the man who would lower himself to such "French penuriousness." I know American mechanics now who declare the common laborer not entitled to a white shirt. I do not comment upon this attitude of mind. I simply state the fact to show our degree of disadvantage whenever the industrially untrained and technically uneducated but mechanically dextrous American mechanic will have to face the economic pinch and the competition of, say, the highly skilled Belgian mechanic with his blue blouse and wooden shoes, his lentils and peas and sour milk, and perhaps a bit of meat on Sunday.

The other day during noon hour I passed along a street where the car track was being relaid, and the men, some forty, were sitting along the curb eating their dinner. They were all Americans, apparently, since with the beginning of hard times last year some corporations discharged all Italian laborers to make temporary room for unemployed Americans. I am always studying the manner of living of working men, and walked slowly along to see what they had in their dinner pails. I did not see a single piece of brown bread with any one, and while some had an egg or a piece of meat, there were many pickles, jellies and other poorly nourishing material, costing money but having little food value. I wish I could have brought some domestic-science teachers along, or taken them through some industrial establishments during dinner hour so that they might learn, not how to teach the children of the American mechanic to prepare dishes which the child's parents reject as good only for the "Dago," but to teach them how to get food value for the money expended.

Whenever the pinch comes, and it will come soon enough at the rate we are traveling, and the belt has to be tightened, the cheaper and equally nourishing diet will come of itself and the domestic-science department of our schools will have prepared the ground for new conditions by training in that skill and knowledge which a turn to changed conditions of life makes possible without great hardship. You see the interdependence of industrial education for the sexes if we want to counteract the forces which now tend to make us lose our industrial standing in competition with our foreign rivals.

To raise money for the establishment of a comprehensive system of public trade and industrial schools should not be so difficult for us if poor Belgium, Germany and Austria can do it. The city of Munich, of 520,000 inhabitants, supports

*Extract from a letter to the Superintendent of Schools, Seattle, Wash.

†Chairman of the Committee on Industrial Education of the American Foundrymen's Association.

48 trade schools and 12 manual training schools. If we had as many industrial schools as the little kingdom of Würtemberg, we ought to have 30,000 schools, in proportion to population. Pennsylvania alone ought to have 1000. A friend of mine in the city of Hagen, Prussia, who is on the school board, wrote me that for the year 1908 they were to expend 33 per cent. of the total taxation of the city for school purposes and even that does not provide for this year's increase of population.

If we would ask an American community to expend that much the school board would be denounced bitterly. In the 1907 annual school report for the city of Hagen I find the expenditure per pupil of the "Realgymnasium," the "Gymnasium" and the "Unterklassen" $88.62—722 pupils. The expenditure per pupil in the "Oberrealschule" $81.67—496 pupils. The expenditure per pupil in the "Lehrerinen-Seminar und Seminarvorschule" $20.30—670 pupils. The expenditure per pupil in the "Hoehere Maschienenbauschule," including evening and Sunday classes, $92.20—240 pupils. The expenditure per pupil in the elementary schools $18.50—14,379 pupils. I do not know what the city's budget was for 1907, but for 1908 it was three million marks, one mark equaling 24.8 cents, and my friend wrote me that there were more than one million marks of that three million appropriated for schools. There were 600 girls in the domestic science or "Haushaltungsschule" and all the boys, of course, were obliged to go to some kind of industrial school until 17 years of age. See why the American consul at Stuttgart, Würtemberg, complains that less and less is imported from the United States and more and more is exported to the United States.

During the last five years Germany has doubled the sale of machinery to the United States, Belgium has trebled it. Yet we proclaim that we are the greatest machine builders in the world. From a report of a special agent, issued by the United States Government last July, to investigate trade conditions in Mexico, I take the following: "While the trade returns afford just cause for a certain degree of satisfaction, it must not be forgotten that competitors of the United States, while holding in comparison but a small percentage of Mexico's trade, are at the same time making more rapid progress." I know of a case where an American agent for a furniture house went to a Mexican town, had to hire an interpreter, was ignorant of conditions, stayed a week and did not sell a cent's worth. Meantime a German agent came along, who could speak Spanish, knew the money and trade conditions, loafed around a week to study the lay of the land and the second week sold $10,000 worth of furniture.

But even if we could command the use of $500,000,000 and could train 100,000 teachers in a week, we would still be handicapped by the retarding traditions of our schools, especially the unfriendliness of the high school toward industrial education in it. We would be handicapped by the lack of the coöperative spirit which makes the school people, the industrial people, the professional people, the lodge, the society, club and church people, the labor union and nonlabor union people, the American, Irish, Scotch, German, Englishman, each go his own way without harmony of purpose and unity of action. In Germany and Belgium these astonishing sacrifices for education are made possible by the unrestrained coöperation of all social forces without reserve and distinction. When it comes to education, the capitalist and the laborer, the monarchist and the socialist work in perfect harmony.

Speaking now from a purely economic standpoint, our high tariff is also a disturbing factor inasmuch as it created a sense of security from outside interference in the great mass of industrial workers, and an unwillingness to train the mind where legislation would protect us from undesirable mental exertion to learn economic production by learning the secrets of the laws of nature, viz., science and technique. Where a large concern could easily learn economic ways of production by sending some bright man abroad who, without stealing secrets or dishonesty of any kind, could learn for an expenditure of traveling expenses better ways of doing things more economically, months and years were spent and material without end was wasted to learn the same thing, painfully and laboriously by experimentation. But now that our great concerns, in their management and methods of production, are coming down to rock bottom and a scientific basis, they encounter the incomprehensibility of the workmen for scientific and economic measures and the ingrained habits of wastefulness, to overcome which disciplinary measures are resorted to, must be resorted to in many instances. These, not being understood, are resented as interfering with American independence, create friction and misunderstanding where there ought to be coöperation and confidence. While, for instance, in Germany, with all the bitterness between socialists and capitalists, the technical civic training of the workers lets them understand technical economic measures and methods of management in the shop; hence the avoidance of unnecessary friction due to lack of technical knowledge.

Summing up, then, the various points in answer to your question whether the United States is likely to lose its industrial standing because of the absence of systematic training of those who enter industrial life, the answer must be in the affirmative as long as we make no concerted and systematic effort as a nation to supply that training. The foundation of our phenomenally rapid industrial development and strength thus far has rested upon the immense wealth of our resources and our free institutions and pioneer spirit of independence which fostered an individualism that rioted in our resources without thought of consequences; while our competitors, due to scarcity of resources and density of population, had to study the laws of nature, to make use of these laws, through the application of science and technique, to the best advantage, to make two blades of grass grow where one grew before.

Their inability to riot amidst limited resources imposed upon them self-control and habits of economy, or starve. This, in turn, produced their splendid system of education, their self-sacrifice, their harmony of purpose and unity of action to maintain and perfect that education. To the degree then as we are approaching this same economic condition, to the degree as our resources diminish, to the degree as density of population and the imperative necessity for greater economy in the use of our resources circumscribes the old traditional pioneer spirit and checks the rampant individualism, to that degree, we, in the United States, must adjust and adapt our educational system to those new social and economic conditions where the study of the laws of nature, the application of scientific and technical knowledge, a sincere coöperative spirit, a high sense of civic duty and responsibility must make up for diminished wealth of resources and circumscribed individual activity.

This is becoming and has become a national issue, and this issue has to be met by an intelligent, liberally supported and universally extended system of trade and industrial schools as a continuation of our elementary schools. And to the degree as we ignore these economic changes, to the degree as we hesitate to recognize the educational necessities of the economic and industrial situation, to the degree that we refuse to make the necessary sacrifices for the industrial and technical training of the mass of our industrial workers, who, in the end will rule our country, by sheer force of numbers if not by intelligence; to that degree will the United States lose its industrial and, as a consequence, its political standing.

Every day in New York city about twice as many passengers travel vertically by elevator as travel horizontally by elevated, subway and trolley car. Figures given in a paper recently read before the Electrical Engineering Society of Columbia University show that the 8000 passenger elevators in the Borough of Manhattan carry approximately 6,500,000 per day; whereas the last report of the Public Service Commission states that the number carried daily by the surface, elevated, and subway cars in the entire city of New York is 3,500,000.—*Scientific American.*

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A Suggested Change in Our Patent System

Our attention has just been called to a striking article by Isaac L. Rice in the *Forum* for March, entitled, "Suggestions for Amendments to our Patent Law." The opening paragraphs of the article contain the most forceful arraignment of the results of our present procedure in patent litigation that we have ever seen. Those who wish to know why such litigation is a good thing to avoid can do no better than to read the article.

The author's conclusions may be summed up in the statement that our present system is a failure. Thus he says: "The question can be treated only from the point of view whether our country has arrived at the stage of production where inventions can safely be discouraged. That the policy now pursued tends to that end admits of no question." Further on, after referring to the early and discouraging years of exploitation of a new invention, he goes on to say: "However, when at last it is recognized as an improvement on existing methods and has, therefore, become a necessity, then the next step is that all hands steal it, with every chance that the patent protecting it will be caught somewhere in the fine net of the litigation and either be declared invalid, or so limited as to make evasion possible and perhaps easy."

The author's conclusions are that the situation demands a radical recasting of our whole system of patent law, including the inauguration of a system of guaranteed patents to which we referred in a recent editorial. To this end he advocates the publication of an official weekly patent gazette containing the full text and drawings of all patents granted during the week of its issue. The patents thus granted are to be provisional for a period of six months, and during that period, subject to proceedings for annulment on the part of the public, in the absence of which, within the specified period, the issue shall take place and thereafter the patent be held valid against the world and subject only to cancellation on the ground of subsequently discovered fraud. Other provisions are made, such as one for a system of compulsory licenses intended to protect existing industries from possible ruin by revolutionary inventions and the limitation of the life of the original patent to seven years with the right on the part of the patentee to obtain two renewals of five years each on payment of suitable fees, but the guarantee feature is the leading one of the system advocated.

The author considers that the present anomalous condition of things springs from the theory which now underlies our patent law which, as he states it, is: "That a patent monopoly is a private privilege derogatory to the personal rights of each individual affected by it, and that, therefore, the right to the privilege must be established anew against every individual contesting it."

Whatever may be the defects of our existing system of patent litigation, and if one knew nothing of them before he could not read this article without a realization that these defects are serious, we do not believe that the remedy lies in the plan laid down, the defect of which is that in its efforts to protect the new inventor it fails to give sufficient protection to the old one. Such a law would require every inventor to search the hundreds of patents issued week by week in order to make sure that a patent infringing on his own had not been issued, and failing to make such search, or to find such infringing patent, he would frequently find himself at the end of the six months' period with the rights to his own invention transferred to another and with no redress.

Fully convinced, as we are, that our patent laws at present do not give the new inventor the protection that they should, we are, nevertheless, not prepared to admit that the old inventor should be put to this burden, or that he should be under the constant danger pointed out. The effect of such a system would be to a large degree to reverse the entire basis of patent infringement. Under the present system the inventor must look out that others do not infringe his patent, while under the one proposed he must be on constant guard that he does not become an infringer of a patent issued subsequently to his own and so buttressed by law as to add a hundred-fold to the penalty of infringement.

At present the chief danger of a patent lies in the discovery that it has been anticipated by older inventions, while the system proposed places the danger in the issue of later patents. The inventor now regards the past with fear, but under the system proposed he would thus regard the future. Surely the light cannot lie in this direction.

Tariff Retaliation Threatened

We are in receipt of a letter from a leading European representative of many American machine-tool builders from which we extract the following:

The friends of American machine tools in our territory were hoping that the new tariff would be based on a desire to exchange manufactured products on a more equitable and fair basis than heretofore. The latest news indicates that the changes recommended so far are generally speaking of an even more unfavorable character than hitherto, not only in regard to the rates themselves, but also in regard to the new method of valuation, and the German and Austria-Hungarian press is already agitating for combining to retaliate strongly against the continuation of

this most unfair basis of exchanging business by boycotting American-made goods. We beg to suggest in this connection that the American technical press make a strong effort to arouse the manufacturers to the necessity of dropping their "laissez faire" policy and of entering an energetic protest.

New Publications

SAFETY VALVE CAPACITY. By Philip G. Darling. 31 6x9-inch pages, 4 illustrations and numerous tables. The Consolidated Safety Valve Company, New York City. *Gratis.*

This pamphlet is a reprint of a paper presented at one of the monthly meetings of the American Society of Mechanical Engineers, together with tables giving the capacities in pounds of steam per hour of safety valves, and other tabulated data. On page 22 are given capacity formulas that cannot fail to attract attention. As indicated above a copy of this pamphlet will be sent without charge to mechanical and steam engineers who apply for it.

THE ENGINEERING INDEX ANNUAL, 1908. 460 6x9-inch pages. *The Engineering Magazine,* New York and London. Price, $2.

It is a pleasure to acknowledge the appearance of this most valuable engineering index. While but slightly larger than the annual for 1907, it indexes 400 more articles; 8248 in all. The gain in range without a proportionate increase in size has been obtained by more careful attention to conciseness in writing the descriptive legends. As before, constant and painstaking care has been used in standardizing the classification, and in the intelligent and free use of cross references. Its predecessors are so well and favorably known that commendation of this annual for 1908 is superflous.

ALTERNATING CURRENT MACHINES. By Samuel Sheldon, Hobart Mason and Erich Hausmann. Published by D. Van Nostrand Company, New York. 1908. Cloth; 360 pages, 5½x8 inches; 236 illustrations. Price, $2.50.

This is the seventh edition of Doctor Sheldon's excellent textbook, and it shows the effects of extensive revision. The original edition of the book impressed the reviewer as being a conspicuously fine example of college textbook, and an honest opinion of the present edition might be regarded as fulsome eulogy, so the reviewer will refrain. It may be well to inform those who are unfamiliar with the work that it is intended for use in technical colleges and not for unassisted study by beginners. It is remarkably clear in exposition, but a knowledge of mathematics as far as elementary calculus is necessary for the student to derive the proper degree of learning from its contents.

STEAM BOILERS. By Peabody and Miller. John Wiley & Sons, New York and London. Cloth; 419 pages, 6x9 inches; 176 illustrations. Price, $4.

Upon its appearance in 1897 this book took a high position in the literature of its subject. Cecil H. Peabody is professor of naval architecture and marine engineering and Edward F. Miller of steam engineering, both at the Massachusetts Institute of Technology. The book has been subjected to a general extension rather than a revision and the additions are distributed throughout the work. A short chapter on Superheaters has been added, also a number of tables giving the dimensions of and floor space occupied by the different types of boiler and economizer. The treatment of steam piping has been especially extended.

GENERAL LECTURES ON ELECTRICAL ENGINEERING. By Charles P. Steinmetz. Published by Robson & Adee, Schenectady, N. Y., 1908. Cloth; 280 pages, 6x9 inches; 48 illustrations. Price, $2.

The contents of this book comprise seventeen lectures and two appendices, the latter being reprints of papers read before engineering societies. The lectures are extremely simple in treatment, practically no mathematics being employed. The author's manuscript was "edited" by J. LeRoy Hayden, and there are many spots where more careful work by Mr. Hayden would have increased the clarity and smoothness of diction very greatly. The lectures are "popular" in character and their scope embraces the whole field of electric light and power engineering; consequently, many of them are conspicuously inadequate, even for the avowed purpose of the book. There are several obscure statements in the book, and one or two which seem to be erroneous, if the reviewer reads aright the author's meaning. On page 104, for example, varying the number of poles on an induction motor is said to be analogous to varying the number of expansions in a steam turbine. The reviewer confesses inability to trace the analogy.

THE MECHANICAL ENGINEERING OF STEAM POWER PLANTS. By Frederick Remsen Hutton. 825 6x9-inch pages; 697 illustrations; third edition; rewritten. John Wiley & Sons, New York City. Price, $5.

This is the revised third edition of a work that was issued originally in 1897. It embodied the study and experience of the author during a period of 20 years in the teaching of engineering. During the last decade the rapid advance of engineering in connection with the power plant and all the departments contributory thereto, rendered it advisable to entire rewrite the work. Thus the present edition has been rewritten, the size of the pages has been increased, new illustrations have been chosen, and many new topics and treatment have been introduced. The former editions of the work are so well and so favorably known that an extended review is unnecessary. The wish of the author as expressed in the preface is that the material brought together may be found serviceable in the work of engineering education. This wish will, we are sure, be gratified in large measure; yet the work will not only be of service in the field for which it was primarily written, but also in the work of the practicing engineer and contractor.

SOCIAL ENGINEERING. By William H. Tolman. 384 6x9-inch pages; numerous illustrations; indexed. McGraw Publishing Company, New York City. Price, $2.

There has been so much broadening of the fields of engineering since the days when engineers either belonged to the military or civil branch of the profession, that we need not express nor feel any surprise at the rise of "social engineering" and the "social engineer." His work has been done during the past decade under such terms as "welfare work" and "industrial betterment." We are now given a new word to use in expressing the relationship that should exist between employer and employee, and to apply to the activities promoted by the social engineer; it is "mutuality." The book is devoted to the problems of the relations between capital and labor; or better, between employers and employees. It is largely a skilful compilation of the experiences of representative firms in various lines of mutuality. Its spirit is indicated by this sentence: "Here and there employers are beginning to realize that investment in manhood pays; that improved men for improved machines have economic value, because a more vigorous man can do more work, a more intelligent man will do more intelligent work, and a more conscientious man will do more conscientious work." Representative means that have been used to improve the manhood of employees, to increase their vigor and intelligence and to quicken their appreciation of their employer's interests and thus their own, are the subjects treated on most of the pages. The work should well serve its purpose; to stir interest in mutuality into constructive action, to serve as a source of suggestions and guidance in industrial betterment work and to show the extent and scope of work already done. The chapter headings are: "Efficiency Promotion;" "The Social Secretary;" "Hygeine;" "Safety and Security;" "Mutuality;" "Thrift;" "Profit Sharing;" "Housing;" "Education;" "Recreation;" "Commercial or Social Beterment;" "Does it Pay?"

New Tools and Machine Shop Appliances

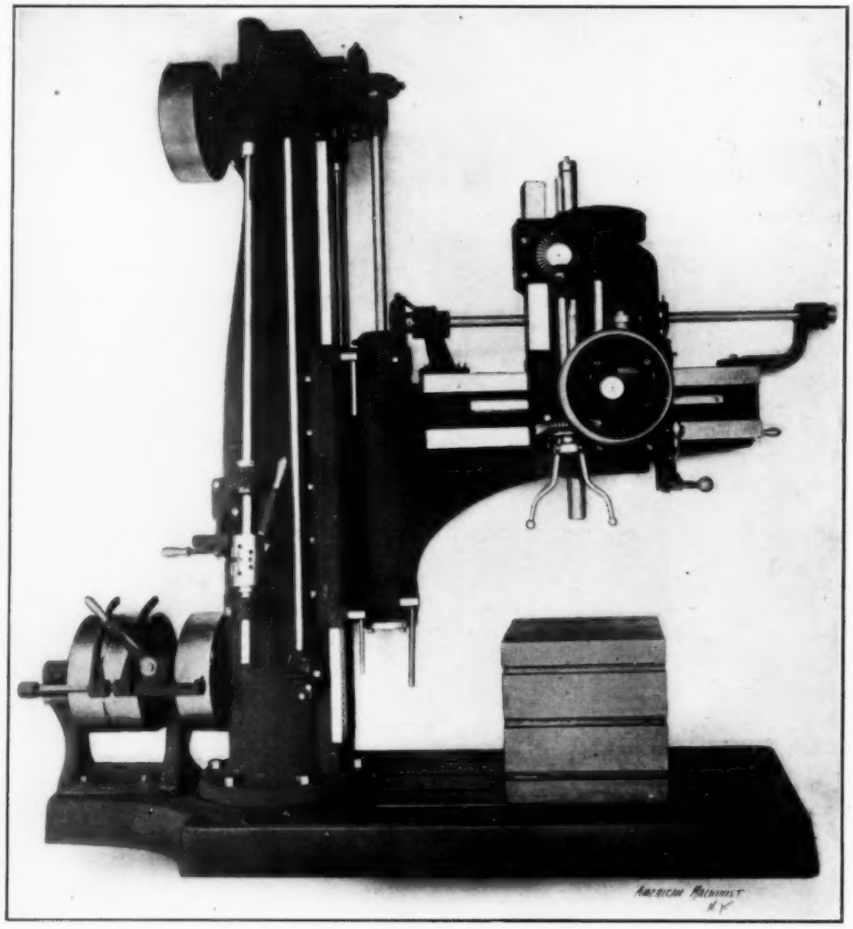
Showing New Ideas in Machine Shop Equipment That Make it Possible To Do Better Work at a Reduced Cost

THE LATEST INFORMATION

Improved "Western" Triple-geared Radial Drill

An improved design of the radial drill built by the Western Machine Tool Works, Holland, Michigan, is illustrated by the accompanying engraving, which brings out clearly the general proportions of the machine, the convenient arrangement of the operating handles, controlling devices, etc. This drill has a self-oiling countershaft which is located on the base of the machine at the back of the column. Both countershaft bearings have individual reservoirs containing enough oil for about a year's running. The loose pulley of the countershaft is also self-oiling and is of single piece construction. Another feature of the countershaft, the belt shifter, will be noticed in the engraving. This arrangement of rack and sector provides such leverage, that the pressure of a finger is sufficient to shift the belt. If desired a constant-speed motor may be bolted on in place of the countershaft and belted to the pulley on the gear box at the top of the column. The mechanism in the gear box at the top of the column is controlled by the speed barrel which is located directly below on the column. A glance at the speed barrel will show that there are eight different speed positions, and the back gears on the head give eight more, making sixteen spindle speeds possible; these ranging from a speed suitable for a 3/8-inch drill to one for a 6-inch pipe tap. As shown, the rod to which the speed barrel is fastened, enters the gear box above. Here it engages with a sector and a rack by means of which the gears are shifted when the speed barrel is operated. The gear box is kept about two-thirds full of oil, and thus all gears and shaft bearings run in an oil bath. From the speed box the power is transmitted through two sets of bevel gears to the shaft on the arm. A set of tumbler gears meshing with the elevating screw and a spur-pinion on the vertical power transmission shaft make it possible to raise and lower the arm with ease, the action of the tumbler gears being controlled by a lever on the column. The arm rests and turns on ball bearings, making easy and quick adjustment possible. Here again a suitable oiling system is provided. The starting, stopping, back gears and tapping device of the triple geared head are all controlled by one handle, making it possible to change from one to the other instantly and safeguarding against engaging two at the same time. All gears in this head run in oil baths.

From the horizontal shaft on the arm three miter gears and a friction clutch transmit the power to the head proper, and make up the reversing mechanism. The power goes to the first set of gears, and, when the friction clutch is up, the drive is direct through to the third set of gears down close to the drill. When the clutch is brought down the drive is through the second set of back gears, and hence to the spindle. This is termed the back-gear position of the clutch, and the whole triple-geared arrangement is brought into action. It should be noted that the spindle is driven at its larger diameter and down close to the work, so that the torsional strain exists only through a short length of the spindle. Eight speeds are made possible by the arrangement of the gears in the box at the top of the column. The triple-geared arrangement in the head gives eight back-gear speeds, making sixteen speeds in all. The feed-gear arrangement for the spindle is inclosed in a casing so that the gears run in a bath of lubricant. The different gear ratios are obtained by two sliding keys which connect the proper gear for the feed desired to the shaft. There are eight feeds ranging in value from 0.008 to 0.060 inch per revolution of spindle. The power feed is transmitted from the feed box through a worm and worm gear, the latter containing a friction clutch which is operated by the two handles shown in front of the spindle. By pressing together the handles, which operate a toggle-joint, the friction ring of the clutch is expanded thus giving a powerful grip. An adjustable wedge is placed between the two fingers, to tighten or loosen the grip as desired. The friction clutch is keyed to the feed rod, thus transmitting the



IMPROVED "WESTERN" RADIAL DRILL

power feed through a set of bevel gears to a spur pinion located between the counter-weight and the quill, and acting on the spindle. This radial drill is built in four sizes 3, 4, 5 and 6 foot respectively.

Starting Panels for Direct Current Service

The use of starting panels for direct-current motors instead of a starting rheostat with separate switch and fuses, is becoming quite universal in a large number of industries, largely because the panel insures a more satisfactory location for rheostat, fuses, switch or circuit breaker, than is often accorded to some of these parts when mounted separately. A line of starting panels has recently been brought out by the Westinghouse Electric & Manufacturing Company, ranging in capacity from a starter for a ¼-horsepower motor at 110 volts to one for a 120-horsepower motor at 220 volts, including panels for 500-volt circuits. These panels are made up in several different styles and can be mounted with wall brackets or on tubular supports resting on the floor. Each panel consists of a slate slab on which are

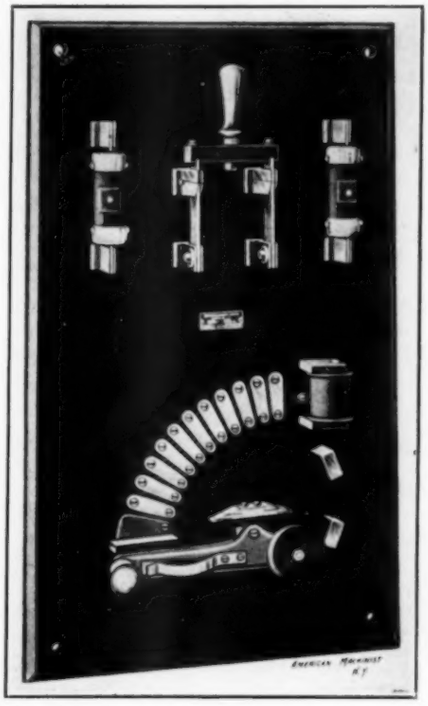


FIG. 2. WESTINGHOUSE TYPE "ZA" STARTING PANEL

FIG. 1. WESTINGHOUSE TYPE "ZB" STARTING PANEL

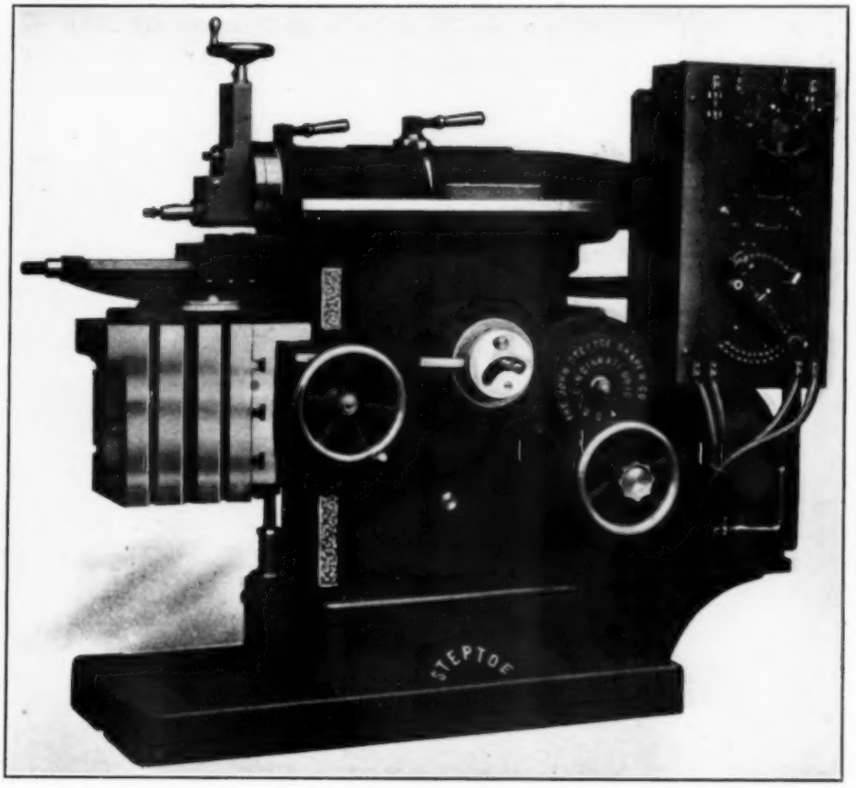
mounted the rheostat contacts and contact arm, the main switch and fuses or the circuit breaker. In the smaller sizes the resistance is mounted on the back of the panel, but in the larger sizes it is mounted separately. Five terminals are provided for connection to the line wires and the motor leads, and are plainly marked so that it is difficult for a man, even if unfamiliar with starting apparatus, to make a mistake in connecting, especially as a diagram is sent with the starting panels.

Fig. 1 shows what is known as a type "ZB" starting panel with a carbon break circuit-breaker, and Fig. 2 shows a type "ZA" panel which has the same arrangement of face plate, contacts, etc., but has a main switch and fuses instead of a circuit-breaker. All sizes are provided with low-voltage release devices which automatically return the contact arms to the starting position on interruption of the power. The low-voltage release coil is independent of the field circuit so that the starting panels are suitable for shunt, series or compound motors. All contacts on sizes over 1¼ horsepower either 110 or 220 volts are renewable from the front without disturbing any connection. In all sizes the initial contacts are protected from burning by a quick-break arcing tip on the front of the panel or by a blowout coil on the rear, which prevents burning the contact on opening the circuit.

Safety Feeding Device for Shaper

The illustration shows a 16-inch shaper recently built for the battleship "Delaware" with the motor, rheostat and controller so placed as to be convenient and at the same time occupy no more room than is necessary for the ram on its extreme backward stroke.

A new feature of the shaper consists in having the feed rod between the eccentric and the feeding ratchet held by friction



A SAFETY FEEDING DEVICE

instead of being positive. This automatically takes care of any variation in length due to feeding the knee up and down the column, as the ratchet movement is limited by horns in each direction. When either of these strike, the rod slides in the clamp and so adjusts itself to the right length.

This also acts as a safety to prevent damage should the knee be allowed to feed to the end of its travel. The shaper is built by the John Steptoe Shaper Company, Cincinnati, O.

A Quick Change Lathe and a Double Back Gear

The halftone, Fig. 1, shows an 18-inch lathe built by the Champion Tool Works Company, Cincinnati, Ohio, to which is applied a new quick-change device of their manufacture.

Mounted on the stud are two change gears of different sizes. Either of these may be driven by a sliding key operated by a push pin which is not visible in the halftone.

These gears serve to communicate motion in different ratios to the lead screw and feed rod through a train of gears. The ratios of the gearing are such that with the one change gear engaged with the stud the long pinion in the gear box rotates at twice the speed of the stud and with the other gear in engagement the pinion rotates at half the speed of the stud.

An idler or quadrant gear is hung from a yoke on the long pinion and transmits its movement to a conical nest of gears on the second shaft of the gear box. The quadrant or tumbler gear is controlled by the small lever with engaging pin shown in front of the gear box in Fig. 1. From the second shaft in the gear box motion is transmitted to the third shaft upon which three gears of various sizes are loosely mounted, any one of which may be connected with the shaft by means of a sliding key which is operated by a controlling knob shown at the right of the gear box and near the top. The knob shaft has at its lower end a gear pinion. This pinion engages with a cylindrical rack formed on the end of the internal shaft, which carries the sliding key. This key rests normally in a recess turned in the gears, there being such a recess between each pair of gears. From the third shaft motion is transmitted to the lead screw. As there are three gears on the third shaft and three positions of the sliding key necessary, therefore three positive positions of the knob which actuates the sliding key are necessary. This is provided for by having three depressions into which a ball, backed up by a compression spring, is forced. This holds the knob and sliding key frictionally, thus preventing its working except when the knob is turned by the operator.

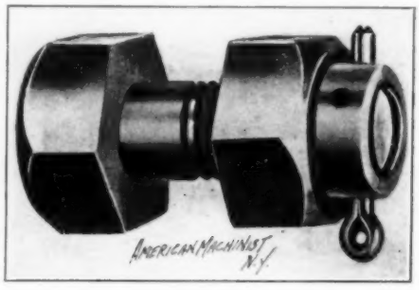
With this arrangement of three simply operated devices, a knob, a push pin and a lever, forty changes of threads and feeds are obtainable without changing a gear.

The head cone is locked to the spindle by a spring-actuated pin in the face gear. The rack pinion can be withdrawn when threads are being chased, and the apron feed reverse is made non-interfering with the lead-screw half-nut, so that the rod and screw feeds can not be both engaged at the same time. The compound-rest and cross-feed screws have dials graduated in thousandths, and the carriage has a chasing dial connecting with the lead screw so that the operator may engage instantly the starting and subsequent cuts on screws without reversing the countershaft or stopping the lathe, which admits of running both countershaft pulleys in one direction, giving (with the back gears) 16 spindle speeds.

Fig. 2 shows a rear view of a double back-gear device manufactured by the same firm and applied by them to their larger lathes. Either of the large gears on the quill can be thrown into engagement by the yoke, which is mounted on a shaft to the front end of which an operating lever is attached. It is thus unnecessary for the operator to go behind the lathe to throw the back gears into or out of engagement.

Turret Lock Nut

The halftone illustrates this lock nut clearly. As shown, the turret nut is provided with six or more adjusting holes, and the bolts or stud on which the nut is to be used has at its end one or two slots which give fine increments of adjustment of from 6 to 24 steps per revolution; for example, in the case of the 1-inch nut with two slots at the end of the bolt, the movement from hole to hole in the nut gives an adjustment of 0.005 inch. It is obvious that as the slot at the end of the bolt is always in view as well as the series of holes in the nut itself, it is easy to locate the holes in alinement with the slot and put the split pin in place, while in the case of the castle nut, the hole which is drilled through the bolt is, of course, hidden from view by the nut. The slot cut in the end of the bolt is of sufficient length to allow a movement of the nut equal to half the diameter of the bolt. The nut is threaded only through the body proper, that portion of the hole extending through the turret being relieved or bored out slightly larger than the outside diameter of the thread of the bolt. This is done to overcome any tendency which might possibly occur for the nut to close the slot in the screw slightly when run on to place and so cause the sides of the slot to grip the pin. When



TURRET LOCK NUT

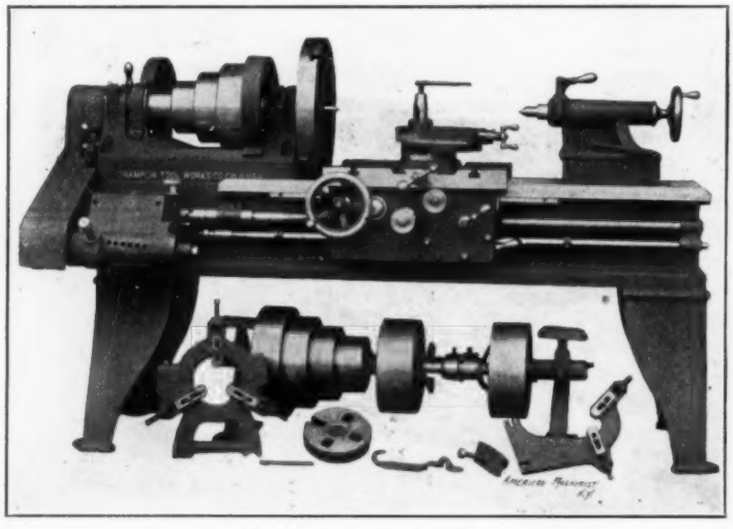


FIG. 1. 18-INCH LATHE WITH QUICK CHANGE GEAR

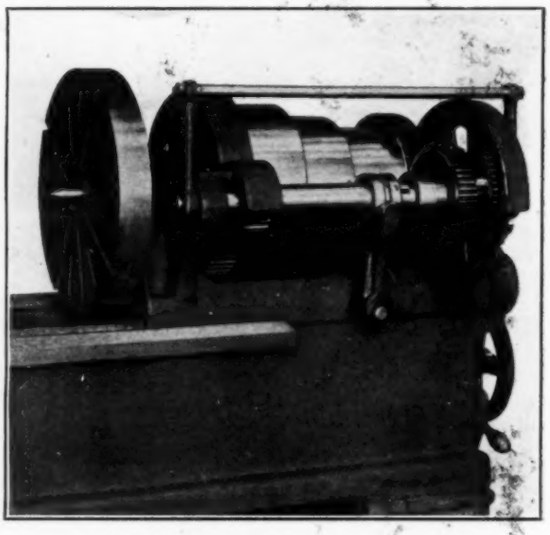


FIG. 2. REAR VIEW OF DOUBLE BACK GEAR

tightening the nut a screwdriver may be inserted in the slot to prevent the bolt from turning. This nut is made in standard sizes from ¼ inch to 2 inches by the Turret Lock Nut and Bolt Company, 1 Clements Inn, Strand, London, England. Inquiries may be addressed to E. Tilston, care of Marwick, Mitchell & Co., 70 Wall street, New York City.

A Single Phase Motor

An automatic single-phase repulsion induction motor has recently been placed on the market by the Bell Electric Motor Company, of Garwood, N. J. Fig. 1 shows the general features of a 15-horsepower size; Fig. 2 shows the rotor and commutator; Fig. 3 the brush holders and brushes, and Fig. 4 the short-circuiting segments. No condensers, phase splitters nor compensators are required.

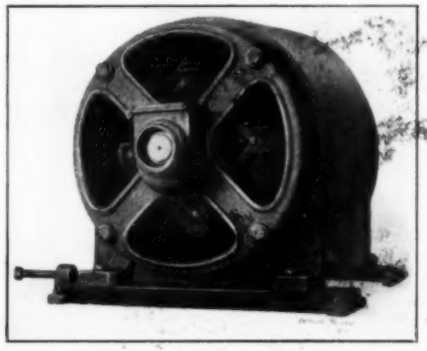


FIG. 1. BELL SINGLE-PHASE MOTOR

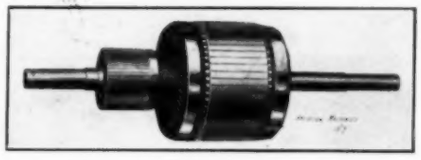


FIG. 2. ROTOR OF BELL SINGLE-PHASE MOTOR

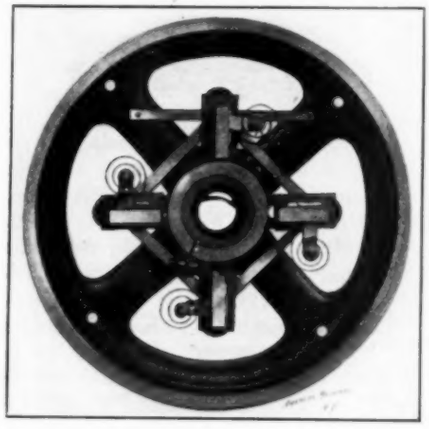


FIG. 3. BRUSH HOLDERS AND BRUSHES OF SINGLE-PHASE MOTOR

FIG. 4. SHORT-CIRCUITING BRUSHES OF SINGLE-PHASE MOTOR

When starting, the line current enters both stator and rotor and brings the motor up to nearly normal speed; then the short-circuiting segments fly outward and short-circuit the bars of the commutator and the motor runs as a true induction motor. The automatic short-circuiting device is very simple, as shown by Fig. 4.

It consists of four copper segments carried on a suitable holder and held toward the center by springs. At a suitable, and predetermined, speed centrifugal force overpowers these springs, the segments fly outward, to a position of contact with the bars of the commutator and the commutator is short-circuited, giving in effect a squirrel-cage rotor. In Fig. 4 the upper segment is shown in short-circuiting position. This entire device enters a bored recess in the outer end of the commutator.

These motors will start under full load, have a high power factor, start very quickly, do not take an excessive starting current and will self-start when current is resupplied after a shutdown.

They are made in sizes from ½ to 15 horsepower and for all standard voltages.

Some New Tool Holders

The Western Tool and Manufacturing Company, Springfield, Ohio, has added considerably to its line of tool holders, the most striking of which is shown in Fig. 1. This type is used only for heavy tools. The holder is in two pieces, clamping the cutter between them with the yoke shown. The serrated edge of the cutter and lower half of holder prevent any end slip of cutter. The turret tool post, shown in Fig. 2, has an angle bracket which clamps to the tool block of the lathe and presents any one of six tools to the work as may be desired. This is made in several sizes to hold regular tools in each position.

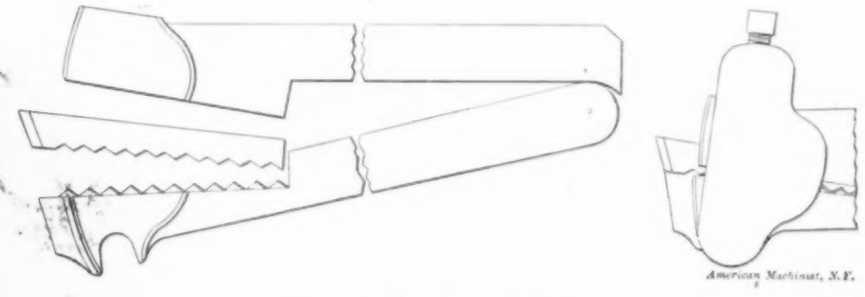


FIG. 1. HOLDER FOR HEAVY TOOLS

They have also developed a line of offset or two-way tool holders, those of the different styles being shown in Fig. 3. The last is double-ended to give either right- or left-hand and still retain the small size of holder at each end.

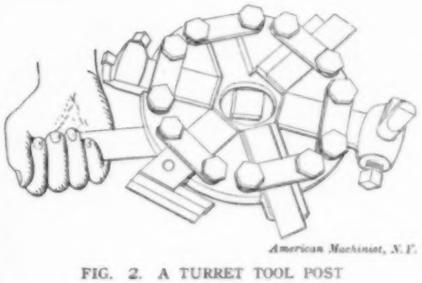


FIG. 2. A TURRET TOOL POST

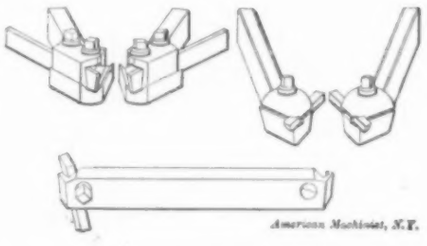


FIG. 3. TYPES OF 2-WAY TOOL HOLDERS

In Fig. 4 are two styles of holders for grinding tools for inserted holders. The tools are clamped to these holders against the proper angle and by moving past the grinding wheel they are ground as desired without further gaging. A new clamp-lathe dog is shown in Fig. 5 in which the tail grows out of one corner instead of the usual place. As shown, it has but one clamping jaw, but for small

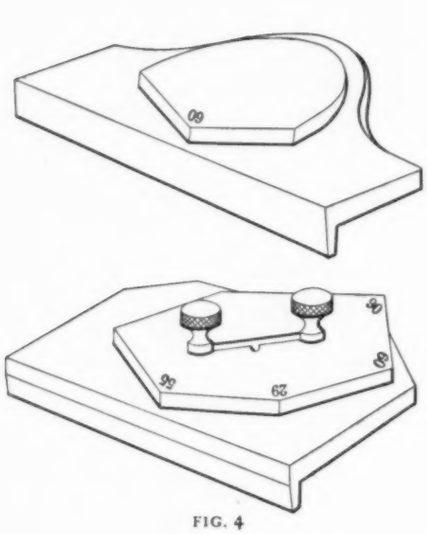


FIG. 4

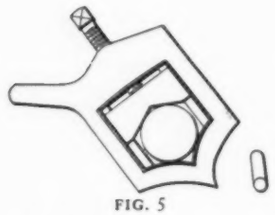


FIG. 5

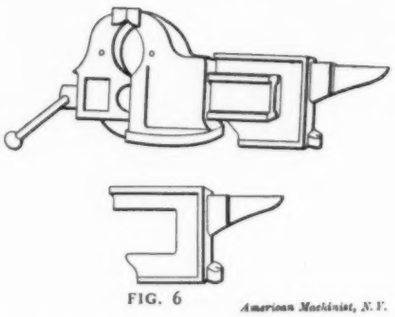


FIG. 6

American Machinist, N.Y.

A GAGE, A DOG AND AN ANVIL

work another jaw is slipped into the bottom of the opening to bring the work nearer central. The use of the portable vise stands made by this company has developed a need for a small anvil to be used in connection with the vise on these stands. This has led to the designing of the bench or vise anvil, shown in Fig. 6, which is large enough to be of real use at all times, as it weighs 25 pounds.

New Core Compound

The S. Obermayer Company, of Cincinnati, O., has developed a compound for mixing or bonding the core sand in such a way as to hold it to shape and at the same time to come out of the casting very readily, leaving it clean and much easier on tools. It is intended specially for automobile cylinders and is known as Esso Core Gum.

Slotting and Milling Fixtures

By U. Steiner

In the accompanying illustrations are shown some fixtures which are in use in the shop of the Landis Tool Company, Waynesboro, Penn. The small pieces machined in these fixtures usually come in large lots, inasmuch as several are needed in one machine. Some time ago one lot of 1000 similar pieces for stationary back rests went through the milling department.

In describing these fixtures we will first consider one for keyseating the bushings, shown in Fig. 1. These bushings, two of which are shown at the side of the fixture, one without the keyways and one finished, are made of 20-carbon steel. Four of these are required for each machine. The plunger described in connection with the jig in Fig. 4 has one end

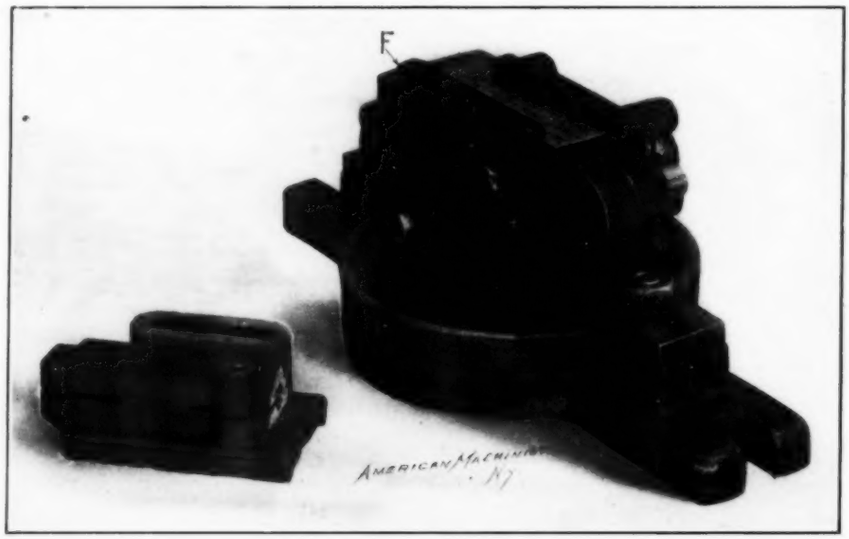


FIG. 2. FIXTURE FOR SLITTING BRACKETS

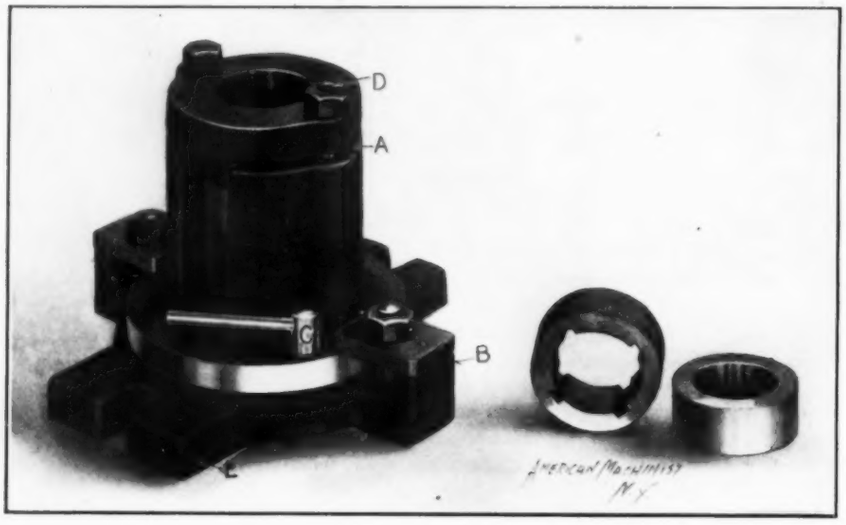


FIG. 1. FIXTURE FOR CUTTING KEYWAYS IN COLLARS

milled to ¼ inch in thickness. This end engages with the keyway in the bushings, Fig. 1, which are pressed into the gears. The spindle passing through these bushings has holes for the reception of the plungers and also a slot for the operating rod—another detail of the 4-speed geared headstock. Reference to the fixture, Fig. 1, shows it to be made up mainly of two parts; *A* indicating the top or revolving part and *B* the base. This revolving piece is machined at the bottom and fits into the base. It is held in position by the clamps shown. The pin *G* reaches through the flange and engages in holes in the base. This is for correctly spacing the keyways. A handle is fastened to the pin to facilitate removing and replacing the pin which is straight and nicely fitted. The fixture is shown loaded, the bushings being held down by the ring clamp *D*. The slots cored in the side of part *A* make

it convenient to remove the bushings. The base has a tongue, shown at *E* which properly locates the device on the key-seater.

The fixture in Fig. 2 is for sawing the plunger brackets, which are of cast iron and form part of the stationary back rest. A plunger from which the bracket derives its name fits into the bracket and the slots in the latter in connection with

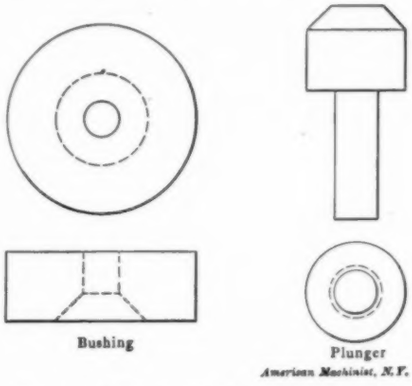


FIG. 3. INDEXING BUSHING AND PLUNGER

put on the arbor and after one is slotted the clamps are loosened leaving the top free to be turned half way around to allow the other end to be split.

The fixture for milling the plungers referred to is shown in Fig. 4. These plungers are used in the 4-speed geared headstocks, four being required for each machine. The material is tool steel hardened and ground.

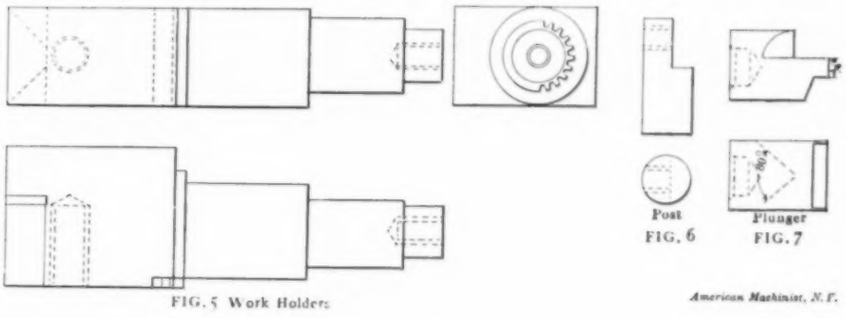


FIG. 5 Work Holders FIG. 6 FIG. 7

DETAILS OF MILLING FIXTURES

for changing the position of the work. At each end of the fixture there is a headless screw with a jam nut, which act as stops, the screw ends coming in contact with the ends of the rack. Posts as shown in Fig. 6, are provided for the stops, these being pressed into the body from the under side. It is evident that moving the handle in either direction will cause a movement of the holders. As the included angle of the plunger face is 80 degrees, as in Fig. 7, the center line passing through the V in the holders comes to rest at 40 degrees from the center line of the fixture. Moving the handle to the other extreme position will swing the holder through exactly 100 degrees.

The shield shown at the front of the fixture, Fig. 4, was removed before photographing. One clamp also is removed to show more clearly the holder. Had the included angle of the plunger been 90 degrees a much simpler fixture could have been devised.

binding screws permit clamping of the plunger. This fixture is also composed mainly of two parts and operates on the revolving principle, as in the case of the fixture in Fig. 1. The top member, as will be seen by referring to Fig. 2, has a circular flange, and in the under side of this are pressed two hardened-steel bushings which are diametrically opposite each other. In the lower part, or base of the fixture, is a hardened-steel plunger which is actuated by a spring; the object of this is to enable the top part to be indexed half way around.

Fig. 3 shows the indexing bushing and plunger. Stops are provided to take the thrust of the work at one end and the other end is fitted with a clamp shown at *F*, Fig. 2. The length of the saw cut is the same at each end of the bracket and, therefore, the stops are so located as to match the castings where the slot commences. Two saws properly spaced are

First, the plungers are turned and one end drilled and centered in the automatic department. The centering at the other end is done in a centering machine. The milling fixture, Fig. 4, is next made use of.

Reference to the halftone shows a body of cast iron with four holes in a straight line and through which is cut a slot to make clamping possible by the five cap screws shown in one of the views. Into these holes are fitted the holders shown more clearly by the drawing, Fig. 5. The ends of these holders which project into the fixture have gear teeth and behind the front plates, which are fastened by eight button-head screws, is concealed a double-edged rack which slides in a slot and the teeth on the inner edge of which engage with the gear teeth on the holders. The teeth on the front of the rack mesh with those of a gear segment *G*, which, as shown, is fitted with a handle that is used

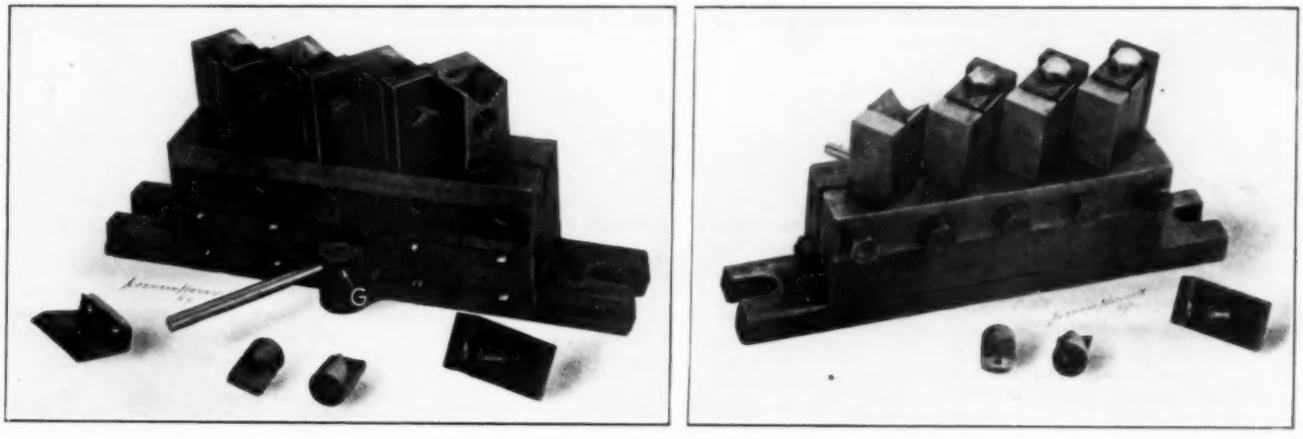


FIG. 4. FIXTURE FOR MILLING PLUNGER FACES

A convenient rule of thumb for ascertaining approximately the size of engine required to drive a direct-current dynamo is to multiply the kilowatts of output by 1.7 for small machines, 1.6 for medium sizes, and 1.5 for 500 kilowatts or over. The result will be about the brake horsepower required.

A Process for Hardening Copper

By H. D. Chapman

Take 2 pounds of alum and 8 ounces of arsenic for every 40 pounds of copper. After mixing the alum and arsenic together, melt the copper in a crucible, then mix the alum and arsenic in with the copper, by stirring it well. After stirring for about five minutes, the copper is ready to pour.

Copper treated in this way is of great density, toughness and hardness and it may be melted a number of times and rolled or drawn without injury.

Forthcoming Meetings

The Foundry and Manufacturers' Supply Association, convention, Cincinnati, Ohio, week of May 17.

National Association of Manufacturers, fourteenth annual meeting, Waldorf Astoria hotel. New York City, May 17; George S. Boudinot, secretary, 170 Broadway, New York City.

American Foundrymen's Association convention, Cincinnati, Ohio, May 18-20, headquarters Hotel Sinton. Richard Moldenke, secretary, Watchung, N. J.

National Machine Tool Builders' Association, spring meeting, May 25, 26, Milwaukee, Wis., headquarters, Plankington house. P. E. Montanus, secretary, Springfield, Ohio.

American Hardware Manufacturers Association, joint convention with Northern Hardware Jobbers Association, Pittsburg, Penn., June 9-11, headquarters, Hotel Schenley. F. D. Mitchell, secretary, 309 Broadway, New York City.

Railway Master Mechanics Association, annual convention, June 16-18, Atlantic City, N. J. Jos. W. Taylor, secretary, Old Colony building, Chicago, Ill.

Master Car Builders Association, annual convention, June 21-23, Atlantic City, N. J. Jos. W. Taylor, secretary, Old Colonoy building, Chicago, Ill.

American Society of Testing Materials, annual meeting, June 29, Atlantic City, N. J. Edgar Marburg, secretary, University of Pennsylvania, Philadelphia, Penn.

Business Items

Wm. J. Smith Co., New Haven, Conn., has appointed Vickers Sons & Maxim, Ltd., 32 Victoria street, London, S. W., England, as sole agents for the one-lock adjustable reamers in Great Britain, France, Belgium, Germany and Austria. The Pittsburg branch of Chas. A. Schieren Company, New York City, has been moved to 205 Wood street.

W. W. Slack, president, Gilman & Son, Inc., H. K. Parkman, secretary, Gilman & Son, Inc., Springfield, Vermont, and G. C. Parker, sales manager, William J. Smith Company, New Haven, Conn., have formed a partnership for the purpose of manufacturing and selling abrasive metal cutters, under the name of Slack Manufacturing Company, Springfield, Vermont; all parties to retain their present positions with their respective companies.

Business Opportunities

The Rochester (Ind.) Bridge Company wil build a new plant.

The Vincennes (Ind.) Paper Company will double capacity of plant.

The King Paper Company, Kalamazoo, Mich., is building an addition to plant.

Dillman Bros., of Geneva, N. Y., will erect a canning factory in Lyons, N. Y.

The Eastman Kodak Company, Rochester, N. Y., will erect a three-story addition.

The Witte Iron Works, Kansas City, Mo., is erecting new foundry and pattern shop.

It is reported the Speedwell Car Company plans enlarging its Dayton, Ohio, plant.

The Brunswick (Me.) Electric Light and Power Company is building a new plant.

The roundhouse of the Cobbs & Mitchell Co. at Cadillac, Mich., was destroyed by fire.

The Detroit (Mich.) Seamless Tube Company is to build a branch plant at Welland, Ont.

The Postum Cereal Company of Battle Creek, Mich., will build a plant at Windsor, Ont.

The Waterloo (Iowa) Cement Tile Machinery Company is building an addition to factory.

The McMillan Lumber Company, Oshkosh, Wis., will erect a new sash and door factory.

The Saranac Machine Company, St. Joseph, Mich., contemplates the erection of a new shop.

The Menasha (Wis.) Paper Company is to erect an additional pulp mill at Ladysmith, Wis.

The Denver (Colo.) Lumber and Manufacturing Company will erect a sash and door factory.

The Moline (Ill.) Foundry Company is said to be considering plans for enlargement of plant.

The Chesapeake & Ohio Railroad is considering the construction of new shops at Richmond, Va.

The Dake-American Steam Turbine Company, Grand Rapids, Mich., is erecting a new plant.

Davidson Bros., Sioux City, Iowa, are putting in a new power plant, approximately 300 horsepower.

The machine shop of Paquette & Co., Quebec, Canada, was destroyed by fire. Loss, about $100,000.

The Salisbury Wheel and Manufacturing Company, Jamestown, N. Y., is to build an addition to plant.

The Chalmers-Detroit Motor Company, Detroit, Mich., has awarded contract for the construction of plant.

The Flint Mills, Fall River, Mass., will put up an additional mill to cost about $500,000, it is said.

The Southern Stove Works, Evansville, Ind., is to erect a new plant for which equipment will be needed.

It is reported the Leader Iron Works, Decatur, Ill., is planning the erection of new machine shop and foundry.

The Fiat Automobile Company, New York, is to erect a plant here for the manufacture of its automobiles.

The W. F. Roth Machine Company, East St. Louis, Ill., will build an addition for general machine repairs.

The Fisher Governor Company, Marshalltown, Iowa, has bought more land for the purpose of extending plant.

The shops of the Gulf, Sabine & Red River Railway at Fields, La., were destroyed by fire. Same will be rebuilt.

C. A. Dunham Company, Marshalltown, Iowa, manufacturing steam traps, etc., will build a new and larger plant.

The George H. Gilbert Manufacturing Company, Gilbertville, Mass., will build an electric power plant at No. 4 mill.

The F. R. Patch Manufacturing Company, Rutland, Vt., manufacturing stone machinery, etc., is building a new shop.

Schram & Sons Co., Oshkosh, Wis., manufacturing rockers, is building an addition and putting in new engine room.

The American District Steam Company will build a new machine shop addition at its plant in North Tonawanda, N. Y.

The Oakville Company, Oakville, Conn., manufacturing piano hardware and brass goods, will build a five-story addition.

Michigan Buggy Company, Kalamazoo, Mich., is erecting an addition to plant. Will put in new engine and other appliances.

The Washington (D. C.), Arlington & Falls Church Electric Railway Company has commenced work on new shops at Lacey.

The El Dorado (Kan.) Motor and Machine Company is building an addition to be used as a garage and repair shop for automobiles.

Sprague & Hathaway, Lynn, Mass., are to establish a shoe factory in Mechanics Falls, Me., which will employ about 150 hands.

The Schantz Hardware Company, of Chappaqua, N. Y., will move to Poughkeepsie, at which place a new plant is being erected.

The Grand Trunk Pacific Railway has commenced work on new shops and terminals near Winnipeg, Man. These will cost $5,000,000.

Parlin & Orendorff, Canton, Ill., manufacturers of plows, is to install new equipment for forging, shearing and punching some time this summer.

The Prest-O-Lite Company, of Indianapolis, making a pressed steel gas tank, will move to Omaha, Neb., where a new plant will be erected.

The Enterprise Foundry and Machine Works, Bristol, Tenn., is to erect a plant for the manufacture of car wheels and general mine equipment.

The Ingersoll-Rand Company has let contract for the erection of new building at plant at Painted Post, N. Y., to be used for heavy machine shop

The Lackawanna Bridge Company, Buffalo, N. Y., a recently organized concern, has purchased site in South Buffalo, on which to build plant.

A new gas stove and steel range factory is to shortly be erected in Battle Creek, Mich. Electric power will be used. P. C. De Voll is treasurer of the company.

The Hill Manufacturing Company, Lewiston, Me., making cotton goods, is erecting a six-story addition. A 700 or 800 horsepower engine will be installed.

The Nieuport Electric Manufacturing Company, of Suresnes, France, has decided to establish a factory in this country for the manufacture of its high tension magnetos. This plant will be located in Detroit, Mich.

The Wisconsin Machinery and Manufacturing Company, Canal street and Muskego avenue, Milwaukee, Wis., manufacturing engines for motor boats, cars, etc., is enlarging plant.

Fire in the Pullman building, Rochester, N. Y., damaged paper-box factory of W. Buedinger & Son to the extent of $5,000. Pullman Manufacturing Company, hardware specialties, $1,500; T. R. Baxendale, machinist, $1,500

A. M. Powell, candy manufacturer, is erecting a ten-story building at Canal and Sullivan streets, New York. Three Scotch boilers, three Erie-Ball engines, two ice machines will be installed. Additional boiler and engine will probably be required.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m., June 10, for valves, cocks, pipe fittings, plumber's furnaces, force cups, steel, brass, copper, copper tubing, bolts, rivets, screws, wire, taps, stocks and dies, wood-boring machine, drill chucks, ratchets, twist drills, saws, hammers, wrenches, tinner's shears, vises, carborundum wheels, flue expanders, differential snatch and tackle blocks, pulleys, belting, etc., as per Circular No. 511.

The American Die and Tool Company, Reading, Penn., wants prices on following machine tools: Warner & Swasey No. 3 hollow hexagonal turret lathe, Bardons & Oliver No. 9 turret lathe, 37-inch capacity, code word "special cedar;" 18-inch by 8-foot bed American improved screw-cutting engine lathe, 18x8 Reade screw-cutting engine lathe, 36-inch Fellows gear shaper, two No.

Thomas Gages and Gaging Methods

Some of the Interesting and Novel Devices Which Are Used to Insure Accurate and Uniform Production in the Thomas Car

EDITORIAL CORRESPONDENCE

The gages and gaging methods in use in the shop of the Thomas Motor Company, Buffalo, N. Y., are extremely interesting in many ways, and show a determination to have the different parts made so as to go together with as little fitting as possible. One of the difficult parts of fitting up the motor is in getting the two cam shafts into correct position with the crank shaft so that the valves may operate nicely and correctly and to avoid all trouble with the meshing of the gears which drive the cam shafts. At the high speed these are run it takes only a very small variation in center distances to make a badly running gear, and noise here is quite noticeable.

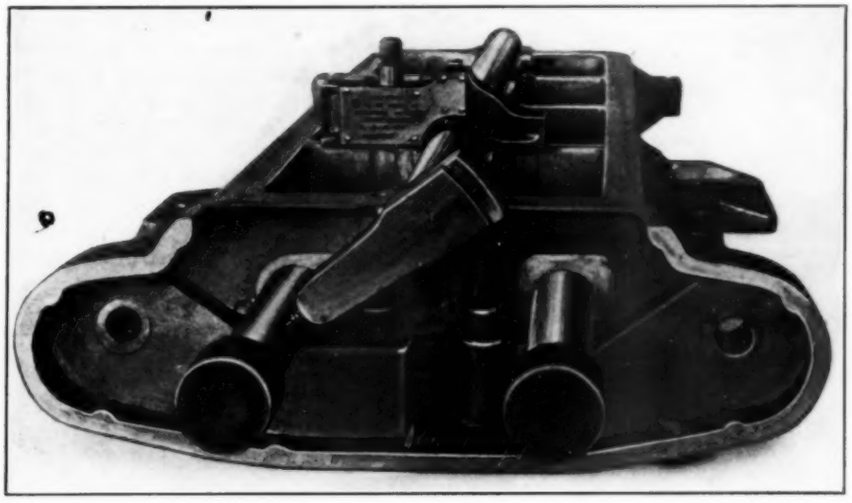


FIG. 1. LINING UP THE CAM SHAFTS

Locating Cam Shafts

After the crank case is bored and faced off it is inspected by the gages shown in Fig. 1. A master shaft is laid in the center or crank-shaft bearings, and from this the cam shafts are gaged. The gage on the end of the shaft is first put on a setting gage, which has two plugs in the correct position, and the feeling point adjusted until the indicator hand is at zero on the scale above. Then the gage is put on the end of the master shaft and swung from one cam shaft to the other and the readings noted. This shows exactly how many thousandths either shaft is out. At the same setting of the master shaft the facing of the crank case is tested by the gage at the back, which rests on the cross-bar of the case and shows how high or low it is. This shows just how much must be scraped to bring everything into line and gives very good results when it comes to the final assembling.

Testing Positions of Cams

The location of the cams on the cam shaft is all important for correct timing of the explosions in the motor, and has probably been the cause of more trouble than many realize. The method of testing the keyways, where the cams are made separately and fastened on the shaft, is shown in Fig. 2. The heavy hexagon hardened and ground steel block or head at the left holds the cam shaft in a fixed position while the other end is supported by a distance block, as shown. The head end of the base plate has two surfaces for this hexagon head to rest on, one horizontal, where it now is, and the other in front and at a determined angle to it. A surface gage with a Starrett dial indicator arrangement, is set at the right hight to bear on one side of the keyways, and the whole affair used on a surface plate. After gaging all the keyways in one position the block is rolled over to the next position and the keyways in that line tested in the same way.

For cam shafts that have the cams solid with them, the testing device, shown in Fig. 3, has been recently devised and is being used very successfully. The base or frame is very similar to the other, but a square block is used instead of a hexagon, two positions being obtained by the angles shown. The measuring device consists of two multiplying levers, separated by a spring and passing over a scale with two sets of graduations. The master cams, mounted on the small stand, form

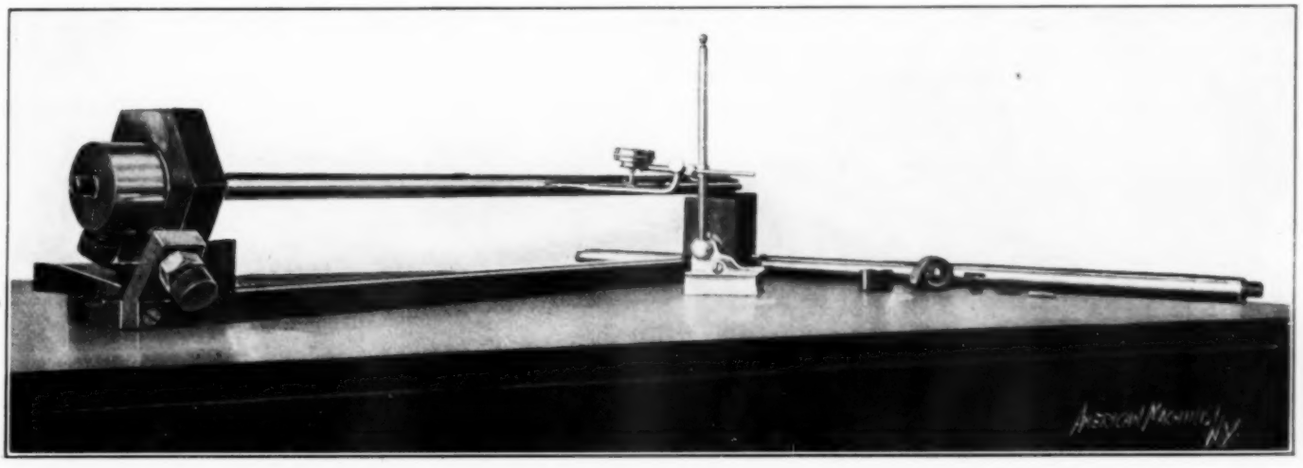


FIG. 2. GAGING CAM-SHAFT KEYWAYS

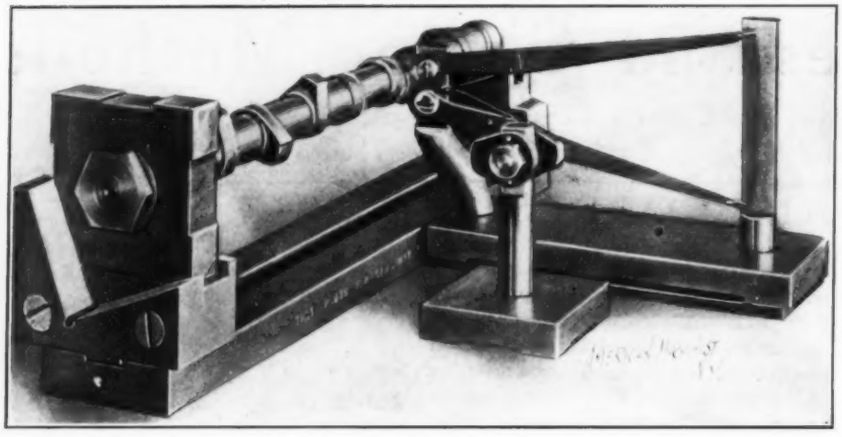


FIG. 3. TESTING CAM LOCATION

reference gages at all times and show whether the indicator has been bent or moved out of adjustment in any way.

Setting the indicating levers on the master cams by pushing the whole base up against the other so that the fingers touch the cam on each side, the indicator is then applied to each cam on this side of the shaft and the indications noted. If the cams are all like the formers the pointers will stand at zero, but any variation will be shown, in thousandths of an inch, so that the exact correction can be made and no guesswork is indulged in. The cam shaft is turned into the different positions being located by the square head, in the same way as the other cam-shaft method.

Testing Error of Threads

Considerable difficulty was experienced in getting threads to match in tapped holes and the suspicion that this was due to error in lead became a certainty when the instruments shown in Figs. 4 to 6 were put into commission. A good sized vernier caliper was fitted with V-shaped measuring points which would handle any threads desired, and the question of setting them exactly 1 inch apart was met in a very interesting way.

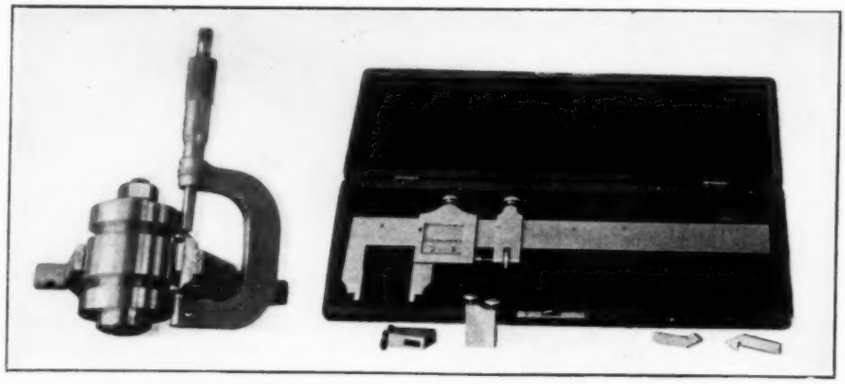
A master or setting piece was built up of three pieces hardened and ground and had V-grooves turned in it, as shown in all three views. The measuring of these grooves was accomplished by selecting two hardened-steel balls that measured 0.25 each, holding them in the grooves with the cross-piece and the C-clamp, and then measuring with a ten-thousandth micrometer, as shown. By working these grooves until the outside of the balls measured just 1¼ inches, gave the correct distance for setting of the points of the vernier.

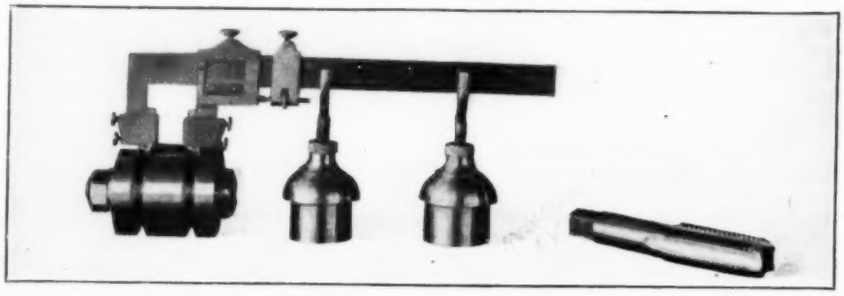
The vernier is then set to these grooves, as shown in Fig. 5, being supported on the V-blocks so as to avoid the effects of heat, and the points are set as nearly 1 inch apart as the skill of the inspector permits. Then the taps to be measured are laid in V-blocks, as shown in Fig. 6, and any error in lead is easily determined. Pieces of threaded work from dies are tested in the same way and give the lead, which can be compared with the taps.

A Group of Gages

In Fig. 7 is a very interesting group of gages used in inspecting some of the many parts. *A* is for testing the location of opposite or double splining or keyways, which is rather common in this shop, and this shows, without doubt, whether they are in the right positions. At *B* is a similar gage for the contour of cams, except that it is hinged instead of being fitted on parallel pins. The permanent surface gages *C* and *D* are easily made and save time. Targets *E* and *F* are used in setting work on planers and milling machines, giving a means of readily setting by bosses or openings and centering by the walls of the casting in much less time by scribing or measuring. These are used quite extensively and have much in their favor. The one at *F* is also a surface gage on the other end, or it might be said the target was fastened to the back of the surface gage.

At *G* are three pin limit gages which are very cheap to make and easy to handle. They are simply hardened-steel pins driven through a piece of tubing making them light to handle. They are marked so as to show the "go in" and "not go in" pins. Next to them at *H* are a few limit gages for Woodruff keys, connected by a nurled





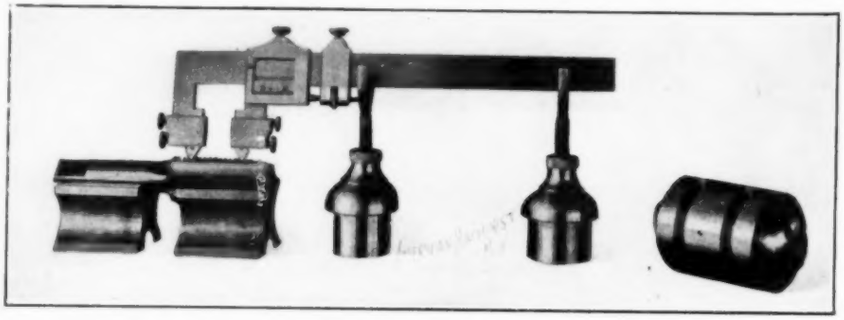


FIG. 4. TESTING THE MASTER PIECE
FIG. 5. SETTING THE VERNIER
FIG. 6. TESTING LEAD OF A CAP

handle and giving both the width and depth of the keyway. At *I* is a thickness gage in the form of a disk, used to test the ring grooves in the piston, their opposites being shown at *K*, which gage the rings themselves. The two grooves define the limits as to what are and what are not permissible in the variations of the rings.

At *J* is a similar gage to that at *A*, except that this is for Woodruff keys and can, therefore, be made solid as the keys can be slipped in place and the ring put over them. This tests both the location and the depth of keyways, as unless they are deep enough the ring will not go on at all. The group of gages at *L* are for machine-screw heads, so as to be sure the counterbores are the right size and depth to make a good job and one that is pleasing in appearance. They are for all the kinds of heads used, those shown including both fillister and countersunk. At *M* is a set of plain keyway gages, the limits being determined by the two ends of the gage, and at *N* is still another set for a similar purpose.

Gaging the Cylinder Bore

For measuring the bore of the cylinders a very ingenious caliper or indicator has been devised and is illustrated in Fig. 8. There is one for each size cylinder, consisting of a cylindrical head and a long tube through which the multiplying lever works across the scale at the end. These measure on the three-point bearing system having two long bearing strips at thirds and the measuring point in the center of the space at 120 degrees from the other strips. Two of these points are shown in front of the gages. Each gage has a ring ground to the exact size of the cylinder and when the gage is placed in the ring, the pointer rests at zero, in the center of the scale. Any variation in either direction is shown in thousandths by the pointer moving in the tube, controlled by the action of the measuring point in the head of the measuring gage. These have proved very successful and show the variation in diameter, if any, at various points of the bore.

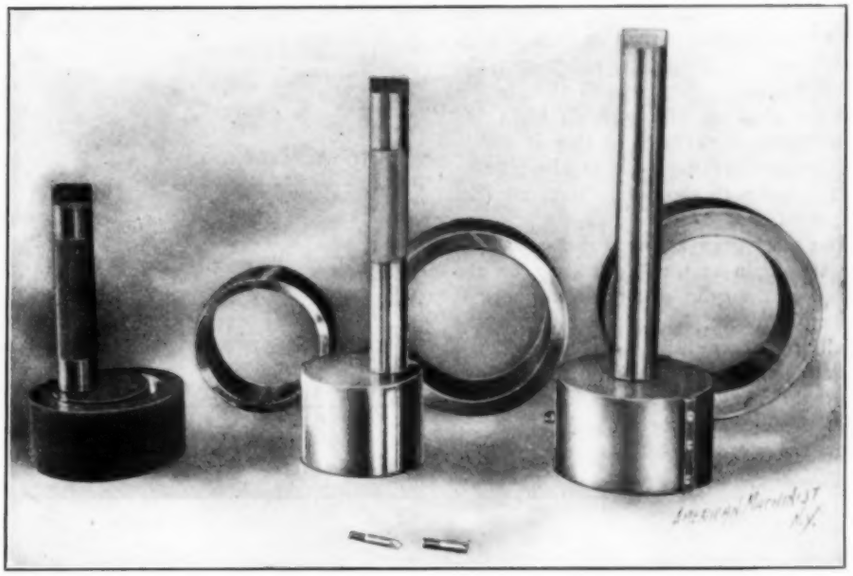


FIG. 8. GAGES FOR CYLINDER BORES

Two other cylinder gages are shown in Figs. 9 and 10, the first for measuring the depth of cylinder to the bottom of the compression space, and the other for getting the length to the end of the bore. These are both what may be called "feel" gages, depending on the feel of the inspector's fingers. The compression chamber is roughed with a flat cutter while being bored, and this shows whether the cutter went into its proper depth or not. If so, the plunger will go in until the inner rod will come just flush with the end of the handle or sleeve, and this cannot only be seen, but can be felt with a far greater

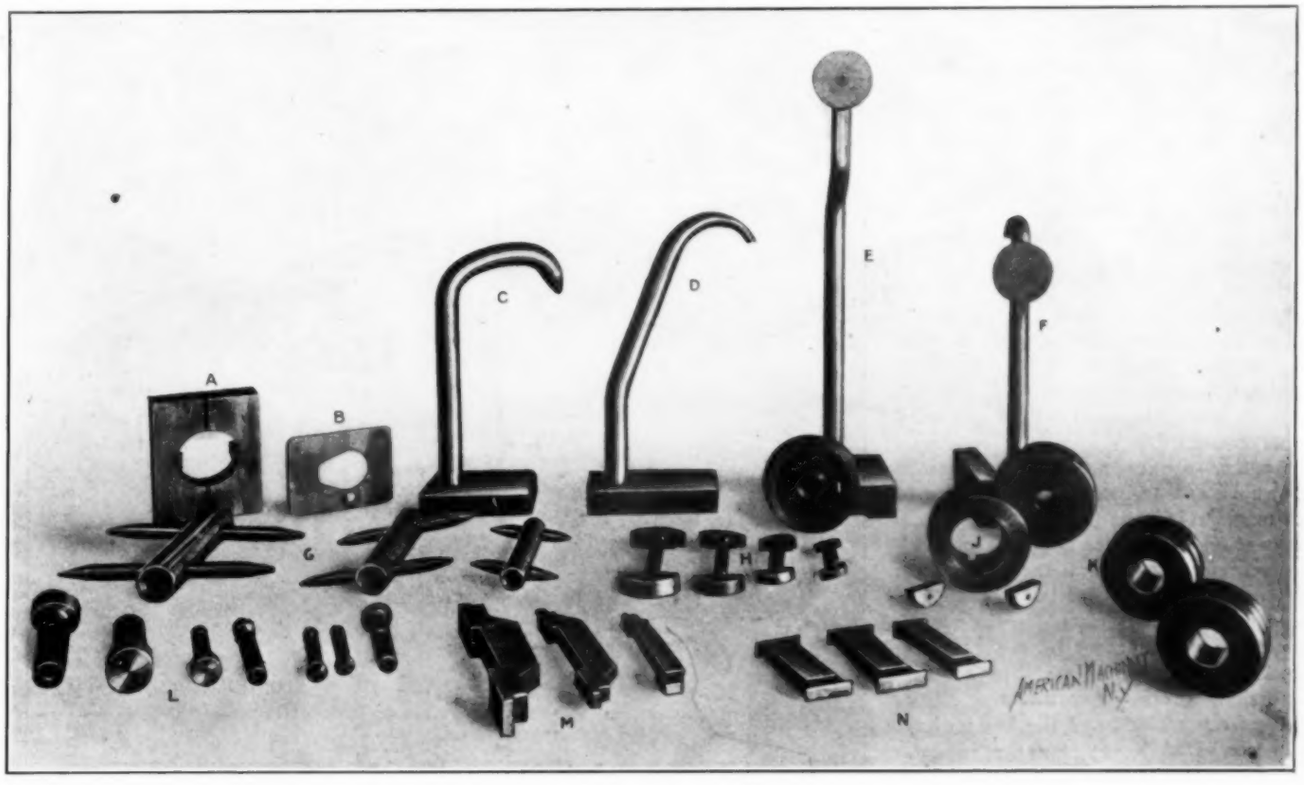


FIG. 7. A GROUP OF GAGES

accuracy than might be imagined by those not accustomed to measuring in this way. The finger or thumb, moved across the end of a piece like this will at once detect the slightest difference in hight between the two surfaces so that it makes a very sensitive gage. It is also graduated in 64ths to show the variations that may exist.

The other gage works in the same way, the small pin at the top resting on the flange of the cylinder and, if the bore is the right depth, being pressed into the small projection until it is just flush. Any variation in this is at once detected as in the other case. This is used in connection with the cylinder boring and is used to show the operator that his work is right.

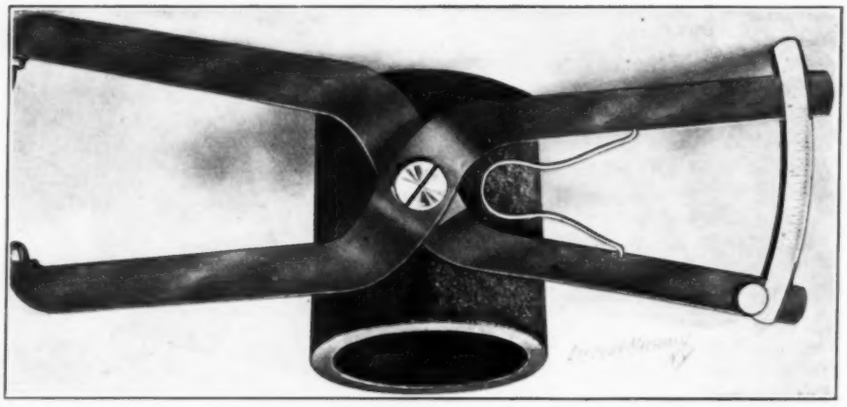
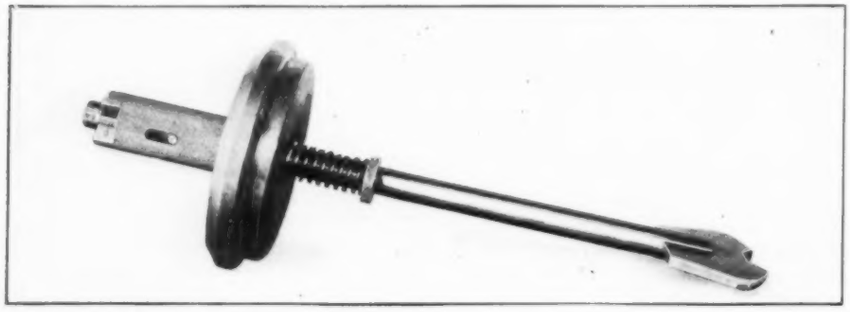


FIG. 11. A REGISTERING CALIPER



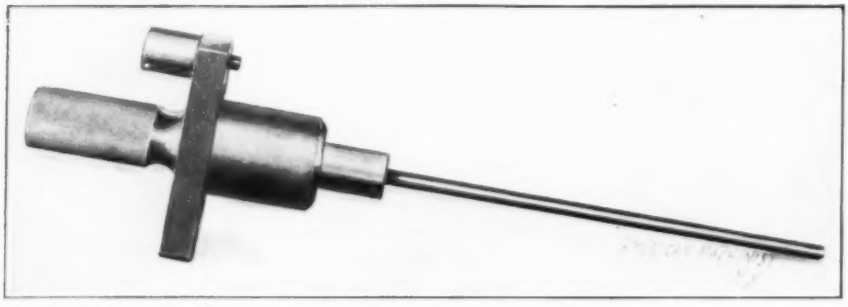


FIG. 9. GAGE FOR COMPRESSION SPACE
FIG. 10. CYLINDER DEPTH GAGE

Caliper for Casting Walls

In Fig. 11 is a simple pair of calipers to show the thickness of walls in a casting, a pipe or similar piece of material where it is not convenient to measure by the usual methods. It is simply a pair of very substantial calipers with both legs or arms of the same length so as to give direct readings at the back end and make it easy to know the condition of the piece being examined.

Another use of the dial indicator is shown in Fig. 12, where the mounting of the magneto is being tested for hight from its base on the surface plate. The standard or reference block at the left is made for three sizes, and after the magneto had been mounted, it is placed on the surface plate, the indicator set by the reference block, a steel collar slipped over to magneto shaft to bring it to the same size as the reference block and the hight of the two compared by moving the indicator from one to the other. When they are alike it is known that the gearing from the shaft to the magneto will run in perfect mesh with the pinion on the magneto shaft.

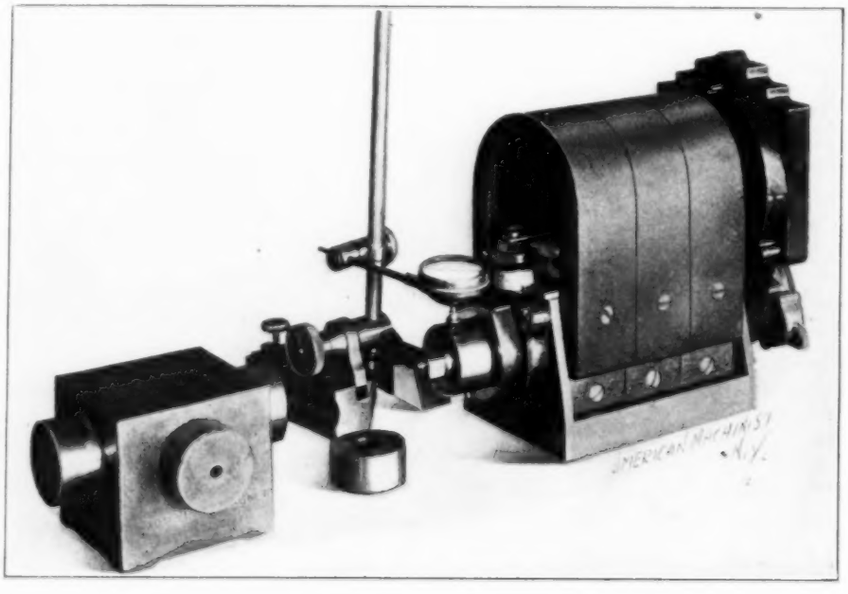


FIG. 12. SETTING THE MAGNETO

Balancing a Crank Shaft

The balancing of a four- or six-throw crank shaft is not an easy job at best, but the way in which they are handled at the Thomas plant makes it as easy as it seems possible to do. The balancing ways shown in Fig. 13 are first accurately leveled and the crank shaft laid on them, resting on its outer bearings. The heavy side will, of course, roll to the bottom. Then the balancing instrument shown on the bench and also in place on the shaft, is put on the end of the shaft with the weight down, as shown. This instrument is in perfect balance in this position, and does not disturb the balance of the crank shaft in the least until the small cylindrical weight on the long rod is raised or moved away from the center. This immediately changes the balance by throwing this weight away from the center and this is continued until the crank shaft is balanced in any position. When this is accomplished, the position of the small weight on the scale is read,

and this gives the ounces that must be removed from that side (which was the upper side in the first position) of the crank shaft. This is done by drilling small holes out of the hub or cylindrical portion at the end of the crank shaft, the balancer knowing what amount of metal is removed per inch of depth for different sized drills. This works out very successfully in practice and gives the balancer more to work to than is often done, making it less of a cut-and-try proposition than usual.

All of these gages have been designed by Messrs. Buxton and Haas as mentioned in the previous article and thanks are also due Miss Mimette Mead, the official photographer of the place, for her painstaking assistance in securing many photographs.

Sammy's Shop—One of Sammy's Mistakes

By W. Osborne

Bertie Brown went through high school up near the head of his class, and he might have been clear at the head of it if he had wanted to be very badly. That is what everybody said who knew anything about the matter, for Bertie was smart, and he came from smart people. Long before he had graduated a place was waiting for him in Sammy's shop, and Sammy felt honored to have such a boy come.

Bertie took a few weeks' vacation to rest up after graduation, and then one day he and his father came down to the shop. Sammy showed them around, introduced them to the men, congratulated Bertie on having finished school and told him what a grand thing it was to be able to serve the world through a knowledge of mechanics. The names of James Watt, Fulton, Howe, and Andrew Carnegie were spoken in a way that showed Bertie that his was at some time destined to be in the same list. While Sammy told of his pleasure in getting and training smart boys Mr. Brown praised the shop and its management. Altogether they had a fine time and were all well satisfied with themselves and with one another. The next day Bertie began the work of skipping up the mechanical ladder, that is to say, "he accepted a situation" in Sammy's shop.

His first work was to help a man who was doing a lot of laying out. This was nice, clean work, and work where it was felt that his education might come into play. It did, for the man declared that Bertie could understand a blueprint as well as he could, and read it much more quickly, and his knowledge of geometry showed him how to get at the laying out in ways that were quicker and often easier than the ways the man was using. Of course, as the man did not have Bertie's education, he had to do the work in his own slow way because he could not follow Bertie's demonstrations, and so could not be sure that the new methods would give the proper results until he had tried both ways. When he laid out a lot of holes by both methods and got the same locations each way he felt confident that in that case both methods were right; still, when a new case came up he feared to use an unfamiliar method. Experience had proved to him that it cost less to be sure of his work than it did to fix it after it had left his hands and been done wrong. The fact that he had done the laying out quickly would not be taken by Sammy as any excuse if it was done wrong. While he was afraid to make use of Bertie's knowledge because it was not familiar to him, yet he respected it. The boy, who had been given a piece of 2-inch pipe to drill full of ⅛-inch holes with directions to drill in twice as many as would be needed, had drilled in 50 so as to have a few for good measure, and he could not yet understand why he had been told to keep on drilling until he had at least 500 holes drilled.

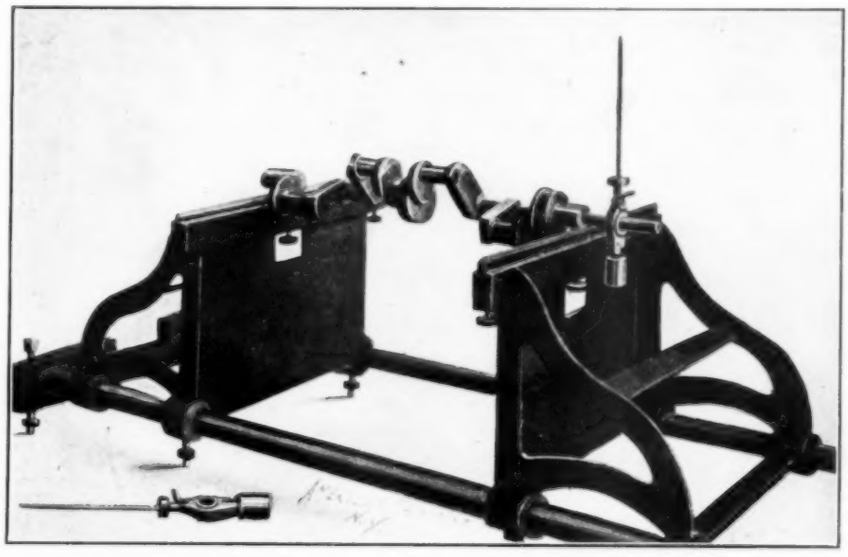


FIG. 13. BALANCING THE CRANKSHAFT

He put the question up to Bertie and felt awed at the wonderful education possessed by a boy who had only been in the shop two days yet who said with very little hesitation that he should have drilled 512 holes. After being showed once Bertie could figure the change gears for screw cutting on any lathe in the shop. One of the old men tried to catch him on telling hom much could be lifted with a crowbar in a given case and tried to make a practical demonstration to show that Bertie's answer was wrong. He got the laugh from his fellow workmen, for the demonstration proved Bertie's figures to be right.

It was not long before Bertie could do any of the common work that the other boys were doing, and he was used to fill their places whenever one of them was absent.

When the draftsman got behind on his work, because of a rush, he was sent to help him and was there for several weeks, and at other times he was there for days at a time.

"Of course," said the draftsman, he is not a draftsman, but he can make blueprints, and doesn't do such a bad job, *for a boy*, at a tracing, and he understands the filing cabinet as well as I do. He is the smartest boy that there is about this place by a long shot." That was so evident that even the other boys did not dispute it.

When a man was sent to do outside repairs and needed an assistant Bertie was allowed to go along and was envied by the other boys. At inventory time he acted as extra clerk and did such work as it was felt safe to put a boy at. He was put at work that no other boy had ever before this been put at. When Mike was sick he had been put on the big lathe and ran it for several days. It is true that the plainest and easiest work was picked out for him, but then even to be allowed to do that was an honor that had never come to any boy before.

Whenever any of the men were telling an outsider about the shop he told of how Bertie was getting along, and Bertie got to have a reputation among the town folks of being a coming genius. All of this did not change Bertie. He was a nice boy, with good manners, and was well liked, and he knew that he was associating in the shop with men and boys who did not have the advantage of the education which he had received, and who were not naturally as smart as he was. If he was doing unusual things it was only to be expected, and he did not deserve any especial credit for doing them.

Time passes quickly, and it does not take long for three years to roll by. Three years put a boy where he calls himself a

machinist, and Bertie had reached that dignity. At the end of his time it was up to a boy to decide whether he wanted to go or stay, and about an equal number decided each way. If a boy stayed he had steady work in his home town, but it took him some added time before he got the full machinists' wages. If he left he had to go into strange surroundings, but some boys had at once gotten jobs that paid them better than the highest wages paid to machinists in the home town. This was exceptional, and there was generally some drawback to these jobs, such as an undesirable location, or disagreeable work.

Bertie decided to leave. He felt that his opportunities were limited in this shop, for it was a small one, and even Sammy himself did not get a salary that was large enough to cause him any trouble in spending it.

Sammy rather encouraged him in the idea. He appreciated the fact that Bertie was smart, and for that reason he had given him opportunities that no other boy had ever received. For all of that, when it came to keeping him as a regular machinist Sammy did not know what to do with him. Bertie was an awfully good boy, but now Sammy had to think of him as a man, for Bertie showed very plainly that with his time served he believed that he was a man and expected to be treated as one.

With a nice letter of recommendation, nice manners and lots of self-confidence it was not any trouble for Bertie to find another place to work. He had more trouble in deciding where he wished to work than in finding a place. The first place was working for a large, well known company.

He was given a lathe and some work and it was evidently supposed that he would go ahead. In Sammy's shop whenever he found anything that he did not understand he asked for information. Perhaps he asked the foreman, or perhaps he asked one of the men. In either case he generally got the information, or else was told where he could get it. In this case he asked the man at a neighboring machine but did not get any friendly response. From the blank look that the man gave him Bertie was not sure that the man understood English, although he did not look like a foreigner.

He tried another man. "If you want to work here you better not let the boss catch you away from your machine," was the reply he got. It was information, but not of the kind that he wanted. His start seemed to be a poor one, and after staying two days he went to look for something else, and did not even go back and try to get pay for the two days.

At the next place he could not feel that the boss neglected him. The fact of the matter was that the boss gave him entirely too much attention, and gave him so many directions as to how things should be done, and pointed out so many details that did not please him that Bertie was very uncomfortable. When Saturday night came this same foreman came around and said: "Young man, I see that you can't do our work. We want good machinists and I would not call you even a good handy man. If we have any work that you are good at let me know and I will try you at it, otherwise I will have to let you go."

Bertie could hardly be sure that he heard rightly. He had seen incompetent men discharged while he worked in Sammy's shop, but had never considered the possibility of such a thing coming to him.

Following along after these experiences Bertie had several very disagreeable ones. At one place he hired out as a lathe hand, and the man in charge wanted him to take the place and keep up the job of an expert who was sick. The work was for a line of machinery which was entirely new to him and when the man learned that he would not allow Bertie to start in.

The man at another place wanted a floor man. Bertie had done some floor work and thought that he might make one in a floor gang. When he found that the floor gang had to set up and test engines, and that it consisted of one man and such laboring help as was necessary to lift and tug, and that if he took the job he would be the one man, he did not take it.

At one place they needed an extra man in the drafting department and he tried his hand there. His education was not enough to make him of use where calculations were to be made and his skill of hand was not so trained that he could hold his own even with the tracer. He did help to make a lot of blueprints, but that was a boy's work and carried a boy's pay with it, and his pride would not let him stay.

Bertie began to think that there were a lot of narrow, close-fisted employers in the world who thought only of getting a man and working him hard to get out of him all that was in him, and that there were a lot of workmen who were only concerned in holding their own jobs.

He did not realize that a shop is buying either skill or education, and that he did not have enough of either to make him desirable. He knew a little bit about quite a lot of things and he had been quick to learn, but when results were to be given in return for pay he could not deliver the goods.

He did get jobs, any number of them, and he did not get "fired" from most of them, although he did get more of that unpleasant experience than many men receive in a lifetime. In the places where he received good wages and where the conditions were such that he would have liked to stay something always happened to prevent it. Sometimes he saw that he was so far outclassed that he quit before anything had a chance to happen; sometimes he got "laid off;" sometimes he was advised to go elsewhere where he "would have broader opportunities to develop;" sometimes he was just discharged and told that he did not suit them.

In the places where he was allowed to stay he did not want to stay. Some of them paid him a rate that was but very little better than laborers' wages; one place was night work and every night in the week; another one was repairing where a man had to work under very dirty and disagreeable and often dangerous conditions, and to work all sorts of irregular hours without any regard to his own plans or desires; at another one the foreman was a rough and profane man who used language that no self-respecting man would submit to having applied to himself.

He stayed for some time in one place. When he applied for a job he did not make any claims for skill but said that he was willing to do his best at anything. The job was a plain one, but this shop was rigged up for it in an unusual way, and the foreman very carefully went over the work with him step by step. The rate which he received was not a high one, but it was explained that it would be increased as his proficiency increased. He did his best and in a short time the rate was changed. Several times it was changed until he was getting full machinists' rate.

As time went on this doing the same thing over and over every day became very monotonous. He asked for a change and was told that they could not afford to change him. The foreman was very frank about it.

"I am careful with a man when I first put him to work. It doesn't so much matter if he is not very quick to catch on if he is only a stayer when he does once get it. The knowledge that they will get the high rate when they get the speed helps to keep them interested, and you see that I have a nice lot of men. Some of them have run the same machine for years."

Bertie saw very little chance for a desirable future in this place, although he was very unsettled as to his own future. The future which he had dreamed about when he first began his life in shop work he now knew had been an unreality, and he had nothing substantial in its place. He was restless and dissatisfied, or as some of his friends said, "ambitious," but he was not striving for any definite end.

One day this foreman brought Bertie an advertisement. A school, or small college, wanted a man to take charge of the shop-work department. Bertie answered it. He found that the pay was small, but as the position was one that gave him some standing he took it.

Sammy has followed Bertie's career at least in part, and he is not proud of his own share in it. He has made up his mind that if he takes in any more extra smart boys they will have to learn things just as thoroughly as the common chap.

and will not be let skip the common things while doing it either. Any boy that is too smart to stand that, he will advise to go to college and stay there until he has education to sell that is worth while. If such a boy should happen around and take Sammy's advice it is to be hoped that he will not get his shop experience under Bertie, for if he does his ideas as to regular shop conditions may not be such as to flatter the shops.

New British High Speed Steels

EDITORIAL CORRESPONDENCE

In view of the interest in the newer high-speed steels, it may be well to add, to the articles appearing on page 586, some further details as to workshop and similar tests.

I visited the firm of Edgar Allen & Co., Ltd., Sheffield, and saw their new Stag brand of steel at work, drilling, turning and milling. The tools used were shown in ordinary workshop conditions. This does not, however, quite apply to the turning tests, the jobs for which were obviously kept for demonstration purposes. For instance, a large steel casting 20 inches diameter in the part machined, containing 0.45 per cent. carbon and having some very hard spots, was shown with the newer steel turning at the rate of 50 feet per minute, the cut being ⅜ inch deep with a ⅛-inch feed. A 1¼-inch square tool was employed. I was informed that this tool will usually hold up for from 15 to 20 minutes without regrinding. It may be worth while to add that the cut takes 28 horsepower. The lathe, made by Noble & Lund, Felling-on-Tyne, was electrically driven by a variable-speed motor.

In a smaller lathe a shaft, 7½ inches diameter, and containing 0.60 per cent. carbon, was run at 115 feet per minute. The cut was 9/64 inch deep with a 1/26-inch feed. I saw 18 inches of this turned. A cut 5/32 inch deep caused the belt to slip, but the firm states that this cut is usually undertaken and that the new Stag brand of steel tool will cut a length of 50 inches without needing to be reground. The lathe on which this test was undertaken was one of the first made by the firm named above for high-speed steels. The speeds were measured by cutmeter on the larger diameter.

Next a steel bar 2 inches thick and containing 0.55 per cent. carbon was put under the drill press, the bar being annealed. A 13/16-inch twist drill was run at 600 revolutions per minute and with a feed of 10 inches. This passed right through the slab at full feed. A 10-horsepower motor is required for driving. I saw nine holes drilled at this rate without any material effect on the tool and was told that usually 15 holes can be cut without regrinding.

As regards milling, a cutter of the newer steel with an angle of 56 degrees, the point being slightly rounded, was shown milling out teeth in rough blanks of ordinary high-speed steel used for saws. The blanks by the same process are simultaneously trued on the diameter. Each blank is about 32 inches diameter and ⅜ inch thick, and when finished contains about 240 teeth. The feed is 1 inch per minute and 80 of these saw blanks (three or more together) are milled without regrinding the cutter. The latter is 5 inches diameter, contains 54 teeth, and runs at a cutting speed of 56 feet per minute. This is a regular commercial job and is in no sense a mere demonstration. The milling cutters themselves are machined by a 3¼-inch cutter, running at about 54 feet per minute, which did 81 cutters before being reground.

In the first turning job the tool was water-hardened, and in the second it was oil-hardened. This is true also of the milling cutters. The firm, in fact, prefers the latter treatment. The temperatures recommended are as follows: for water-hardening 2200 degrees, Fahrenheit, oil-hardening 2280 degrees, Fahrenheit and air-hardening 2375 degrees Fahrenheit.

One firm at least, J. J. Saville & Co., Ltd., Sheffield, is now recommending higher cutting speeds, the increase suggested for cast iron being about 50 per cent. over ordinary high-speed steel rates, and for forged steel from 25 to 40 per cent. In these conditions the two sets of steel will cut for equal lengths of time without regrinding. When, however, the cutting conditions are not altered but endurance is required, as in certain milling cutters, the new Triumph Superb steel tools are found to last, on forged steel, about four times as long as ordinary high-speed Triumph steel, without regrinding. On cast iron the ratio is from between 7 and 10 to 1.

The new high-speed steel, while as tough as the ordinary high-speed steel, is easy to machine and it is, therefore, expected to find a ready market for milling cutters. This firm also prefers air- or oil-hardening, but the steel will water-harden if necessary.

Some tests were made with J. J. Saville & Co., new Triumph Superb steel in the shop of a well-known British toolmaker. The first test was surfacing a faceplate 42 inches in diameter. By a special device the cutting speed was kept constant at 100 feet per minute. The depth of cut was 3/16 inch and the feed 1/9 inch per revolution. The whole surface was machined in about 14 minutes and the tool was left in excellent condition for more work.

For the purpose of comparison an ordinary high-speed-steel tool was tried and failed instantly at this speed, while another brand of the new high-speed steel, water-hardened, ran only 2 minutes under the same conditions and was done up. The Saville tool cut several other plates of the same diameter on the same speeds and feeds. The material for the face plate is described as medium-hard cast iron containing upward of 0.60 per cent. combined carbon and 2.60 per cent. graphitic carbon.

In planing, the same steel was used on some very hard cast-iron beams employed in textile work, the cutting speed being 40 feet per minute. On these beams it is stated ordinary high-speed steels have never cut a length of more than 20 feet, while the Saville tool cut 50 feet, and was still in fair condition. These results were obtained by the Triumph Superb steel tools, air-hardened.

Malleable-iron castings which had been rejected as too hard to machine, because they could not be touched by ordinary high-speed steel, were planed with the new steel with no difficulty at a cutting speed of 50 feet per minute. On several other castings of a slightly softer character a cutting speed of 140 feet per minute was maintained, without injuring the tool in any way.

In Scotland a firm is regularly turning steel forgings at 240 feet per minute, with ¼-inch reduction of diameter and a feed of 1/16 inch. A tool made of Triumph Superb has machined annealed high-speed steel of the same brand at 145 feet per minute.

An addition may be made to the notes on double mushet steel supplied by Samuel Osborn & Co., Ltd., Sheffield. The writer was shown a ¾-inch twist drill running at 526 revolutions per minute, with a feed of 6 inches per minute, that was drilling holes 2½ inches deep in hard steel. Twelve of these holes were drilled without regrinding the tool; whereas with the ordinary standard high-speed drills the speed usual is 376 revolutions with a feed of 5 inches and the tool would have to be ground after drilling six holes. Then 13/16-inch drills of the new material are in use in the Clyde works of the firm, running at 400 revolutions per minute with a feed of 3½ inches. A drill has cut through 14 inches steel billets at one operation. The drilling of these long holes is ordinary everyday work at piece rates.

J. W. C.

According to *Cassier's Magazine* the largest transmission line in the world is that of the Niagara-Syracuse-Auburn line, which transmits 30,000 horsepower over a distance of 163 miles. The line in parts is designed to carry 60,000 horsepower. The Colgate plant, Yuba River, Cal., connects *via* Oakland and Mission San José to a line 222 miles in length. This plant has a capacity of 11,250 kilowatts and there are over 100 sub-stations on 1375 miles of circuit on the system.

A New Transmission Dynamometer*

A Compact, Rigid, Coupling-like Instrument That Can Be Used for Either Rotation of the Shaft and Can Be Read at a Distance

BY WM. H. KENERSON

I have received from time to time many requests for a simple transmission dynamometer, and have often felt the need of one which would be more generally applicable than those now in use. These continued requests, together with the requirements of a definite problem whose solution demanded a rigid transmission dynamometer in the form of a coupling, led to the design and construction of the instrument described below. The accompanying illustrations show the construction of the dynamometer and its method of application and use. In Figs. 2 and 4 the corresponding parts of the dynamometer are given the same letters and are referred to in the text.

The couplings *A* and *B*, each keyed to its respective shaft, are held together loosely by the stud bolts *C*. The holes in the flange *A* are larger than the studs *C*, so that these studs have no part in transmitting power from one shaft to the other. The power is transmitted from *A* to *B* through the agency of the latches *L*, four of which are arranged around the circumference of the flange *B*. These latches are mounted and are free to turn on the studs *E*. The two fingers of the latches engage the studs *F* on the flange *A*. On the ends of each latch are knife edges parallel to the stud about which the latch turns. For either direction of rotation of the flange *A* the latches *L*, which are in effect double bell-crank levers, will exert a pressure on the disk *G*, tending to force it axially along the hub of the coupling *B*, and this pressure, it will be seen, is proportional to the torque.

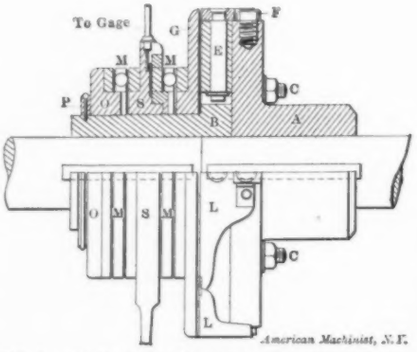


FIG. 2. TRANSMISSION DYNAMOMETER SHOWN IN SECTION

Between the end-thrust ball, or roller, bearings *M M* is held the stationary ring *S*, which is the weighing member. *O* is a thrust collar screwed on the hub of *B*, and *P* is its check nut, which is ordinarily pinned to the hub when in position. The stationary member *S*, in the form of a ring surrounding the shaft, is prevented from rotating by fastening to some fixed object the attached arm shown in the view, Fig. 1, of the assembled instrument. In the ring is an annular cavity covered by a thin, flexible copper diaphragm *D*, against which the ball race of one of the thrust bearings presses. The edge of this ball race is slightly chamfered to allow some motion to the diaphragm. The cavity is filled with a fluid, such as oil, and connected by means of a tube to a gage. The oil pressure measured by the gage is proportional to the pressure between the thrust-bearings, which in turn is proportional to the torque.

The instrument may be calibrated in the torsion-testing machine, or by means of a sensitive friction brake. Fig. 6 is an actual calibration curve for a small instrument, obtained by hanging standard weights at proper distances from the shaft on a horizontal lever attached to the shaft, and reading the pressures indicated by the gage for the various torques shown in the diagram. For ordinary purposes, however, it is not necessary to calibrate the instrument by actual trial, since computations of the oil pressures for the various torques from the lengths of the lever arms and diaphragm area check very closely those thus obtained.

It will be seen that the weighing means is similar to that employed in the Emery testing machine, which is recognized as

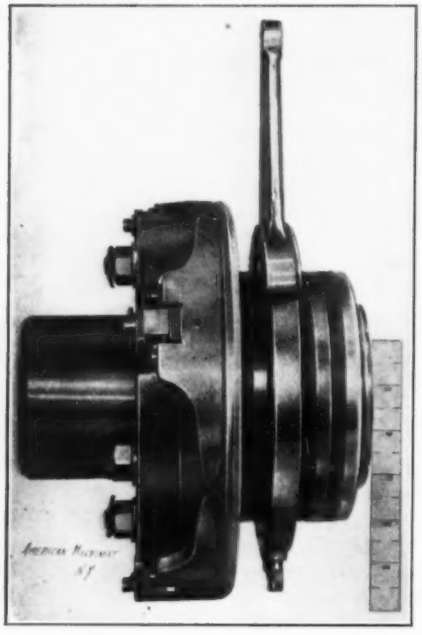


FIG. 1. TRANSMISSION DYNAMOMETER FOR 2-INCH SHAFT—WEIGHT 60 POUNDS

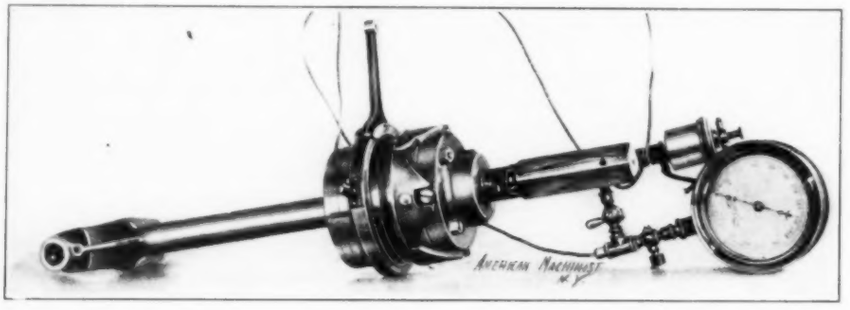


FIG. 3. TRANSMISSION DYNAMOMETER IN AUTOMOBILE PROPELLER SHAFT—30 HORSE-POWER AT 500 REVOLUTIONS PER MINUTE, WEIGHT 25 POUNDS

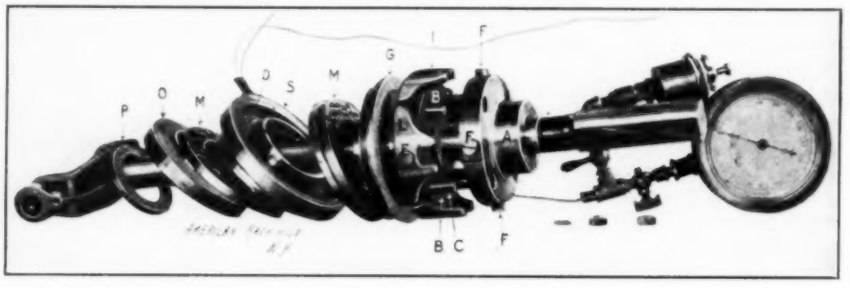


FIG. 4. TRANSMISSION DYNAMOMETER DISASSEMBLED TO SHOW CONSTRUCTION

*Slightly condensed from the *Journal* of the American Society of Mechanical Engineers.

being extremely accurate. It will be possible to employ the Emery flexible steel knife-edges on the levers, if desired, but this has been found in practice an unnecessary refinement.

The construction makes the coupling as nearly rigid as materials will permit, the movement of the diaphragm being extremely small. The only flow of oil through the copper connecting pipe is that sufficient to alter the shape of the Bourdon tube, if that be the form of gage employed. As soon as the normal position of the gage is reached this flow ceases, hence there can be no fluid friction. It is possible, therefore, to use as long and as small a tube as desired, without introducing error. Where the gage is placed at a distance above or below the coupling, correction should, of course, be made for the static head.

Other means than the gage shown may be employed to measure the fluid pressure. Where extreme accuracy is desired it will be well to employ the weighing device used with the Emery testing machine. The manograph has been used in this connection to measure variations in torque too rapid for indication by the ordinary gage. For example, the variations in torque in a single revolution of the shaft of a three-cylinder gasolene engine have been recorded with its aid.

Where the rate of rotation of the shaft is variable and it is desired to indicate the horsepower direct, the combination of gage and tachometer shown in Fig. 7 is employed. The hydraulic gage is connected to the coupling described, its pointer, therefore, indicating torque. The pointer of the tachometer shows the number of revolutions per minute. Being a function of the revolutions per minute and the torque, the horsepower will be indicated by the intersection of the two pointers and suitable curves on the dial, as shown. Arrangements for recording or integrating the work done may also be attached to the coupling.

A summary of some of the more important characteristics of the instrument follows:

a. The instrument is compact. The example shown in Figs. 3 and 4, which is designed to transmit 30 horsepower at 500 revolutions per minute is about 5⅜ inches in diameter and weighs about 25 pounds. That shown in Fig. 5 driving a 3-inch shaft is about 13 inches in diameter and weighs about 160 pounds.

b. It is as rigid as an ordinary flange coupling.

c. It may be made in the form of a coupling, and will then occupy about the same space as the usual flange coupling, or it may be made in the form of a quill on which a pulley is mounted. This form may be made in halves for application to a continuous shaft.

d. It will indicate for either direction of rotation of the shaft.

e. The torque may be read and recorded or the work integrated at a considerable distance from the coupling.

f. The readings do not require correction for different speeds of rotation. All parts containing oil are stationary, hence are unaffected by variation in speed. Other parts are likewise unaffected by centrifugal action.

g. It may be made very sensitive and accurate. The construction lends itself very easily to variation of range of application and to varying degrees of sensitiveness, since the oil pressure, and hence the sensitiveness of the instrument, depend upon the area of the diaphragm, the relative lengths of the arms of the latches *L*, and the diameter of flanges. Its accuracy is dependent mainly on the degree of accuracy of the means employed to measure the fluid pressure, of which a number of forms, other than the usual pressure-gage, are available.

h. The only power absorbed is the small amount due to the friction of the ball, or roller, bearings, and this can be determined from the pull of the retaining arm. It is unnecessary to make correction for this, however, since the amount is so small as to be negligible.

i. Since the only wearing parts are the ball, or roller, bearings, which may be lightly loaded, the instrument should not be deranged easily. Because of the very small volume of oil contained in the weighing chamber, ordinary temperature changes do not affect the calibration. All parts containing oil are stationary, hence all joints may be soldered and leakage entirely prevented.

j. With suitable material and ordinary workmanship, it is believed that there is

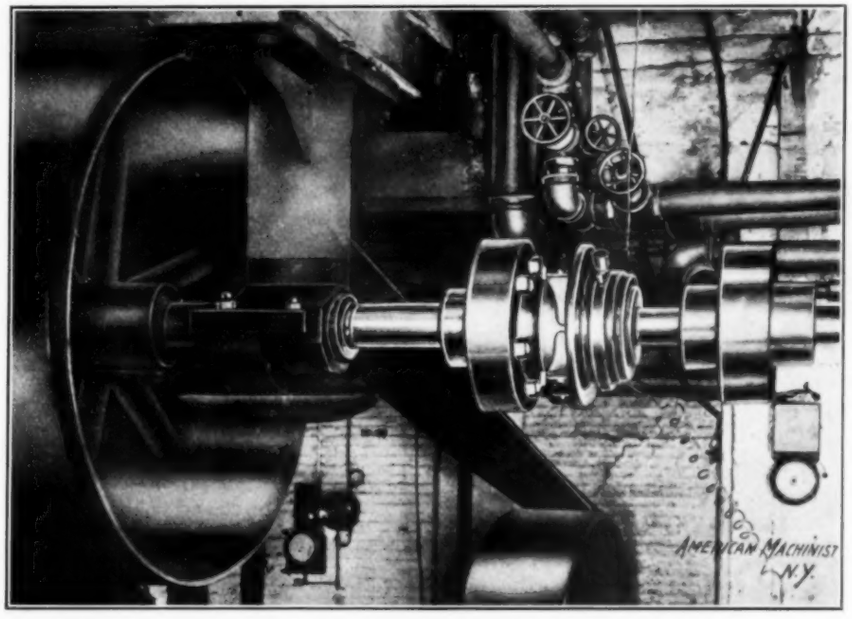


FIG. 5. DYNAMOMETER IN A LINE SHAFT IN A MACHINE SHOP—SHAFT 3 INCHES IN DIAMETER

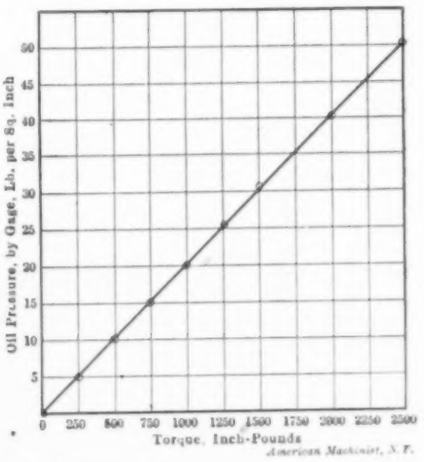

Oil Pressure, by Gage, Lb. per Sq. Inch
0 5 10 15 20 25 30 35 40 45 50
0 250 500 750 1000 1250 1500 1750 2000 2250 2500
Torque, Inch-Pounds
American Machinist, N.Y.

FIG. 6. CALIBRATION CURVE FOR TRANSMISSION DYNAMOMETER

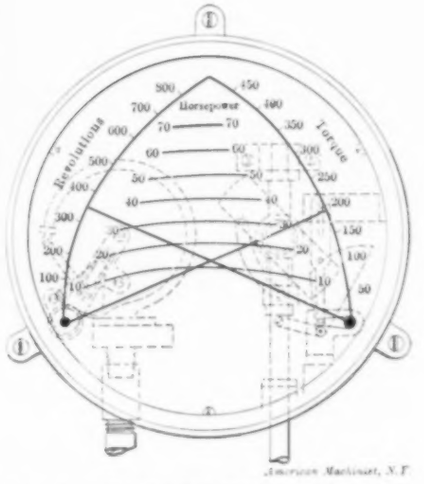


FIG. 7. COMBINATION PRESSURE GAGE AND TACHOMETER INDICATING TORQUE, REVOLUTIONS PER MINUTE AND HORSEPOWER

little likelihood of failure of any part of the instrument. It is conceivable, however, that the balls, or rollers, although lightly loaded, might crush; the diaphragm might shear; or the stationary member, although bearing only its own weight and lubricated, might seize to the hub. Remote as are any of these possibilities, should any or all of them occur, the worst that could happen would be the tearing off of the oil pipe and retaining arm, when the whole would revolve as a solid coupling. In no case can the coupling fail to drive the shaft because of its variation from the standard form, since, in addition to the driving latches employed to carry the load normally, the same number of connecting bolts may be employed as in the ordinary coupling, which will still hold the coupling together should the latches fail. Since, however, these latches are farther from the shaft, they should, if properly constructed, be less likely to fail than the connecting bolts usually employed.

An Interesting Grinding Job with Fixtures and Appliances

A very unique job of internal grinding is shown in Fig. 1. This was done in the shops of the Heald Machine Company, Worcester, Mass., on one of their internal grinders, and is the first case we know of where this method has been used to finish the inside of a terra cotta tile pipe. This was 8 inches in diameter and 14 inches long, it being necessary to remove about 3/8 inch from the inside. It was used for a special valve in connection with the handling of acids, the outside of the plug being ground by the Norton Grinding Company on one of their machines. A soft wheel was used and the time taken on the piece shown was 9 hours.

Fig. 2 shows one of these machines in the shop of a gasolene engine builder, being used on the work for which it was designed and also shows the exhaust connection for taking away the dust and grinding.

Fig. 3 shows the same machine rigged up for grinding piston rings by the use of a magnetic chuck mounted on a suitable head and being revolved by an independent belt, as shown. It will be noticed that a cord has been tied around the handle which controls the rotary movement of the grinding head so that the grinding wheel remains stationary.

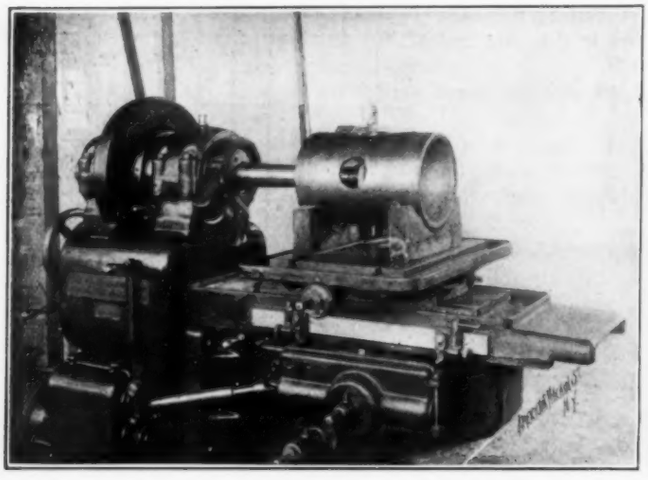


FIG. 1. GRINDING A TILE PIPE

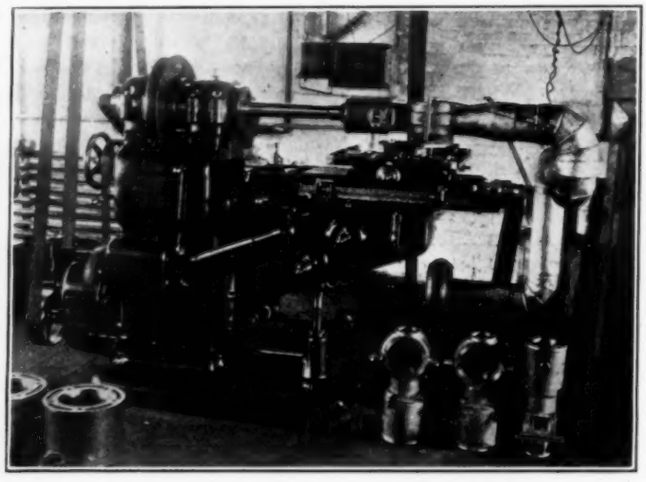


FIG. 2. EXHAUSTING FROM CRANK CASE

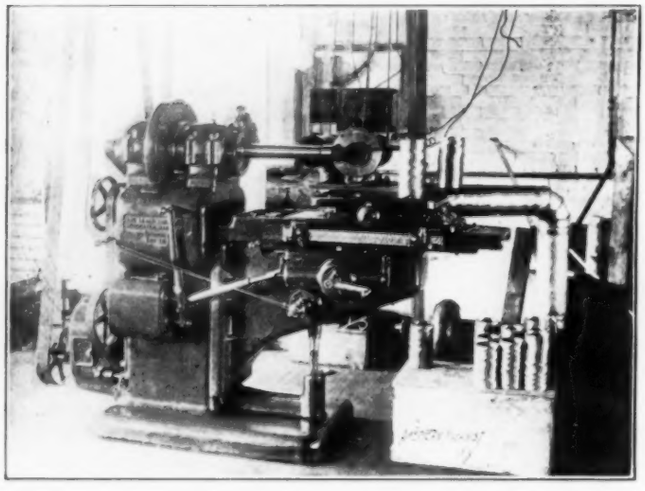


FIG. 3. GRINDING PISTON RINGS

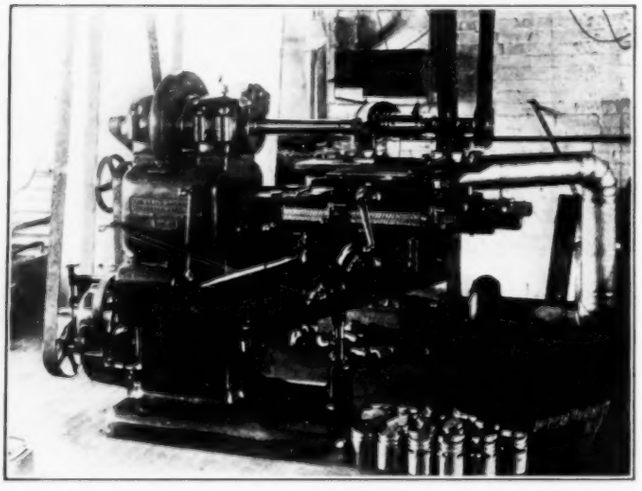


FIG. 4. GRINDING PISTONS

In Fig. 4 is still another adaptation of this same machine, this kind being used for grinding the outside of the piston. The same string is in evidence for keeping the wheel in the same position, and a small table with the head carrying and supporting the piston while being ground has been mounted over the regular table. These show some of the uses, aside from those for which it was designed, that a machine of this kind can be put to.

Fig. 5 is a small view of one of these machines at work in the Stearns Com-

pany's shop on one of four cylinders cast in one piece, as is being done at present by some of the automobile builders. Fig. 6 shows a very heavy fixture for holding cylinders to be ground, used by the Premier Motor Company, of Indianapolis, Ind.

In Fig. 7 a machine is equipped with a large armored hose for carrying away the exhaust from the valve openings and is a somewhat unusual application. Fig. 8 shows another case of exhaust outlet being very large, having an area several times that of the cylinder itself.

Fig. 9 illustrates a most consistent shop. The air-cooled cylinders are cooled in grinding by the electric fan above the cylinder in addition to the exhaust taking away the dust and chips.

Fig. 10 is a unique outdoor wash room, in which the pipe shown comes from the waterjacket of the gas engine and is tapped at various points so that warm water can be drawn off in the basins as shown. This was taken by Mr. Searle, grinding expert of the Heald Company, in contrast with their own extremely neat wash room with porcelain-lined basins and may almost be called the latest example of "open plumbing."

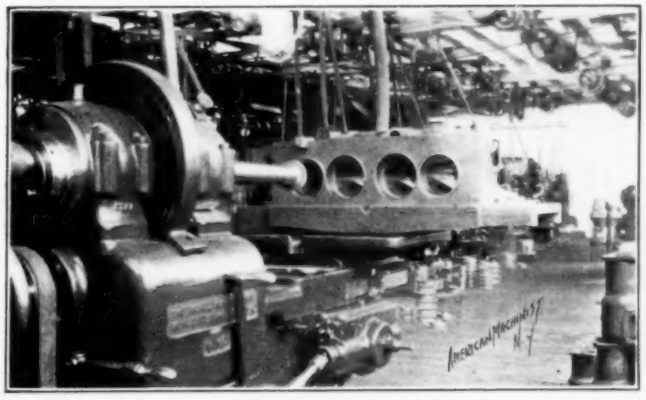


FIG. 5. FOUR CYLINDERS CAST TOGETHER

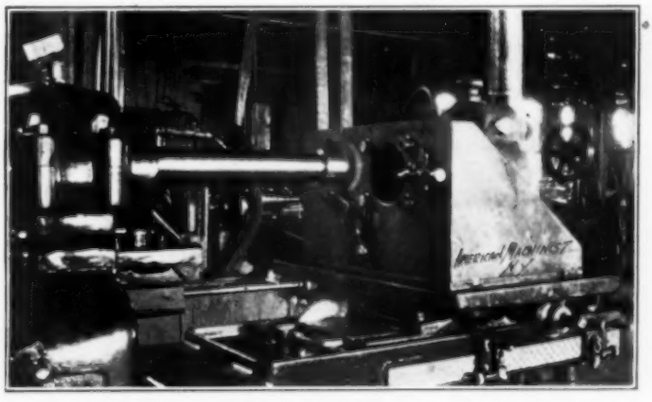


FIG. 6. HEAVY ANGLE IRON

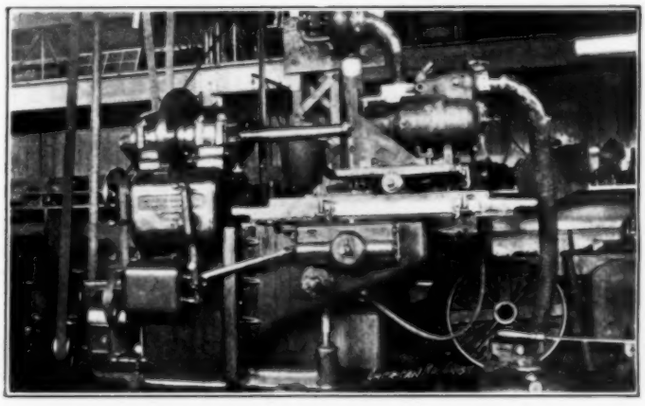


FIG. 7. USING HEAVY ARMORED HOSE

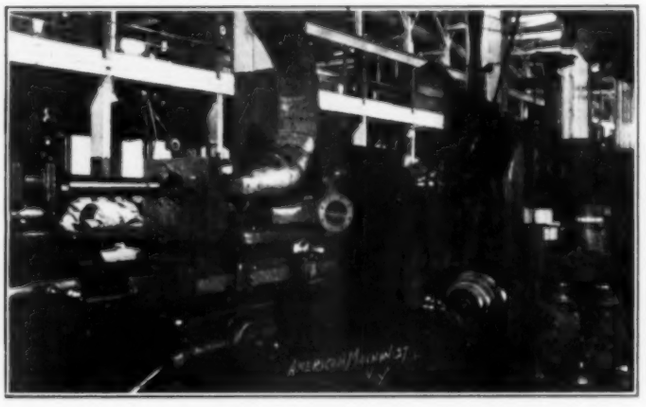


FIG. 8. HEAVY STOVEPIPE CONNECTION

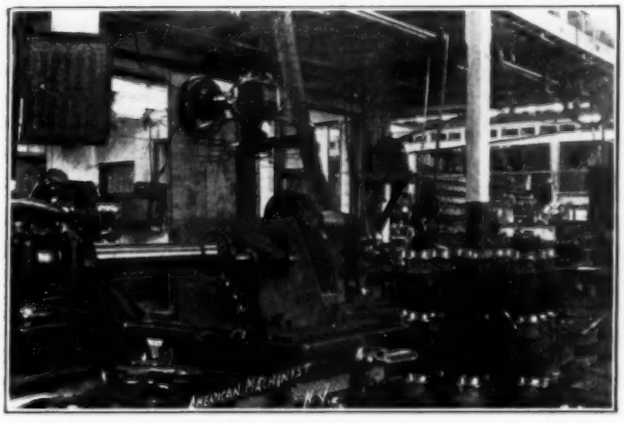


FIG. 9. AIR-COOLING THE CYLINDERS

FIG. 10. OPEN-AIR WASH ROOM

Industrial Education in Baltimore

A large meeting was recently held in Baltimore, in the interest of industrial education, under the auspices of the United Settlement Workers' Association. Dr. Budiner, of Johns Hopkins University presided and Professor J. C. Monaghan, secretary of the National Society for the Promotion of Industrial Education delivered the principal address.

His address dealt with many phases of progressive industrial education and was well received by a large and enthusiastic audience.

The Manufacturing of United States Money

Methods in Uncle Sam's Finest Money Factory, the Philadelphia Mint, Where with Machinery of Extreme Accuracy, Bullion Is Turned into Coin

EDITORIAL CORRESPONDENCE

While all manufacturing has for its final object the making of money, the establishments where money itself as a final product is actually manufactured are limited to but a few places in any one country. What is probably the finest money factory in the world is located in Philadelphia, where, in a magnificent, new building equipped with all modern minting appliances, many millions of dollars worth of gold, silver and copper money are turned out every year.

Gold and silver coins of the United States Government are required to be 90 per cent. pure metal and 10 per cent. copper alloy. The five-cent piece is 75 per cent. copper and 25 per cent. nickel. The one-cent piece is 95 per cent. copper, 2½ per cent. zinc, and 2½ per cent. tin. The weight of all the pieces must conform within a very narrow margin to the standard weight which is also set by the Government. There is a very slight margin plus or minus allowed, as it is, of course, impossible to make all the pieces of exactly the correct weight. This margin, however, is very small, and consequently the turning out of money within the allowed variation of weight requires very accurate methods and continual weighing and checking throughout the process.

The bullion, or crude metal, is received by the Mint officials in the deposit or weighing room, each deposit being kept separate until paid for. It is next melted, assayed and its exact value determined, and upon this value depends the price which the Government will pay the depositor for his bullion. The weighing is done on a very large pair of balance scales, having a beam about 6 feet long and standing about 8 feet from the floor. This scale is exceedingly accurate, and is constantly adjusted, and is capable of weighing anything from the one-hundredth part of an ounce up to almost 700 pounds.

FIG. 1. THE MELTING ROOM. PHILADELPHIA MINT

The Separation of the Metals

Gold and silver usually occur in nature in the same vein, and the bullion deposits are often in this form. It is, therefore, necessary to separate these two metals and also to refine them before they can be turned into coin. There are three well known methods of separation: The nitric-acid process, the sulphuric-acid process and the electrolytic process. The Philadelphit Mint uses the nitric-acid process, which turns out gold between 997 and 999 parts in a thousand fine. The Philadelphia Mint also employs the electrolytic process to a small extent, but as this process requires bullion of a certain degree of fineness to work commercially, the use of the process is limited.

With the nitric-acid process the gold and silver bullion is first melted in crucibles over a gas fire, and then granulated by dropping into water. This dropping of the molten metal into the water breaks the metal up into irregular particles and lumps which present a very great surface to the action of the acid. These granulations which have been taken from the water are treated with nitric acid and the solution is kept hot and intermittently stirred for about 6 hours. The silver in the bullion is, of course, dissolved in the

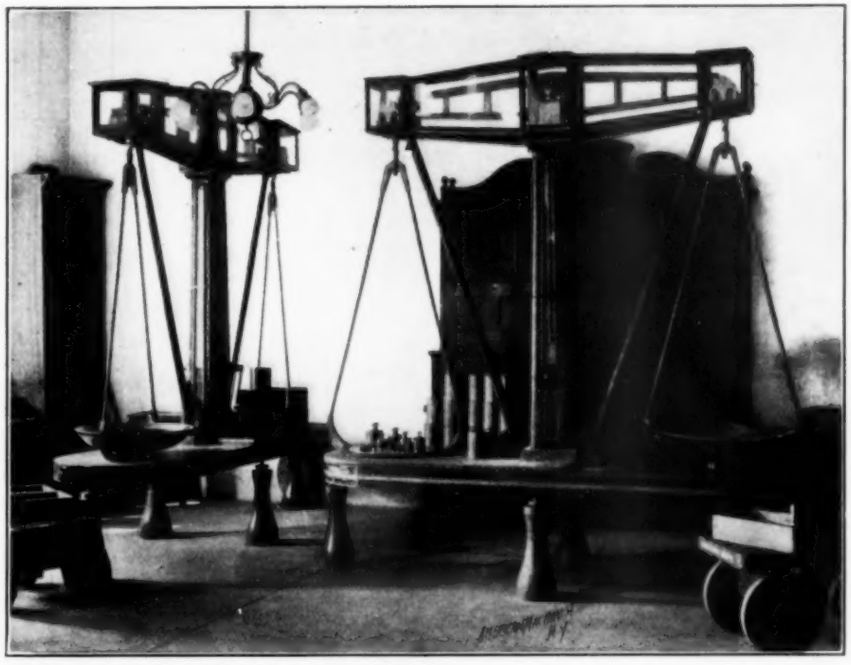


FIG. 2. THE BALANCE SCALES

acid, and the gold is left in the bottom of the vessel in the shape of a brown powder. Repeated treatments with nitric acid are made to insure entire solution of the silver, and after this the gold residue is washed and filtered through cotton cloths, then boiled with concentrated sulphuric acid; this final acid treatment serving to further insure the entire removal of the silver. Finally, the gold particles are carefully washed, dried and melted, and then cast into bars worth about $8000 each.

The silver nitrate which was formed by the action of the nitric acid on the silver is treated with salt water, which precipitates silver chloride in the form of a white milky deposit. The silver chloride is washed several times with water and finally treated with granulated zinc. The zinc reacts on the silver chloride, forming zinc chloride and metallic silver, which latter is then pressed into cakes in hydraulic presses, and these cakes are dried and melted. They are then cast into bars, the fineness of which is between 998 and 999 parts in a thousand.

The electrolytic process of refining the gold is simply a matter of gold plating, as bars of the bullion are hung in tanks containing an acid solution and by the action of an electric current, the gold is deposited on metal plates hung on the opposite side of the tank. This method gives the purest form of gold but, as said, it can be applied only to bullion of a certain degree of fineness.

Casting

All of the pure gold and silver, which is turned out by the various refining processes, is melted separately, and there is added the 10 per cent. of pure copper to make the standard alloy for gold and silver coin. The melted alloy is poured into iron molds which are greased on the interior to prevent the metal from sticking, and the bars cast are about a foot long by 2½ inches wide. When made of gold these bars are worth about $1200, and when made of silver are worth about $60. One melt of silver will contain about $3600 worth of metal, and one melt of gold will contain about $130,000 worth of metal. The silver requires a melting heat of 1800 degrees Fahrenheit and the gold requires about 2000 degrees. The furnaces in the new Philadelphia mint are heated with naphtha gas, which is a great improvement over the old coal-fired furnaces. In this way the temperature is easily regulated, and everything is much cleaner.

The cast bars are next dipped in water to cool them, and then in a weak solution of sulphuric acid to remove the grease. Next the rough upper end of the bar is cut off in a shearing machine, and also the fins are filed off the bars, the filings dropping down into a metal tray underneath the vise in which the bar is held. These trimmed bars are then piled on trucks, marked with the melt number, and at the same time a small piece is cut from one of the bars, this sample to be assayed in order to determine the fineness of the melt. The requirements for the gold and

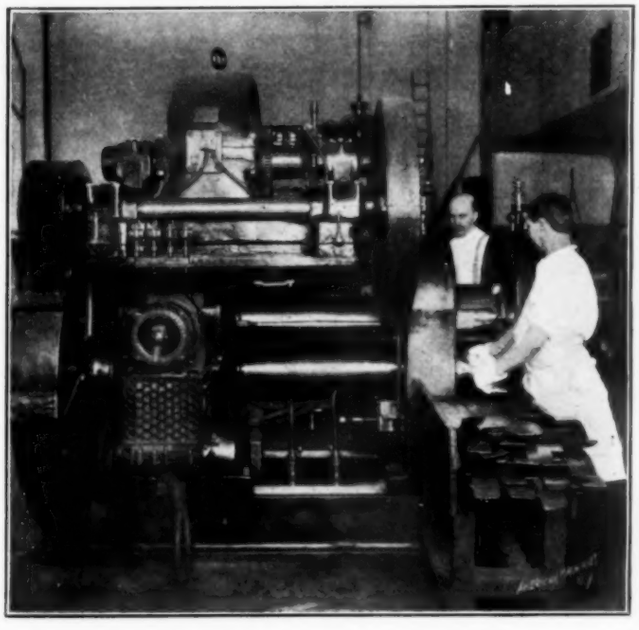


FIG. 3. ROLLING THE METAL

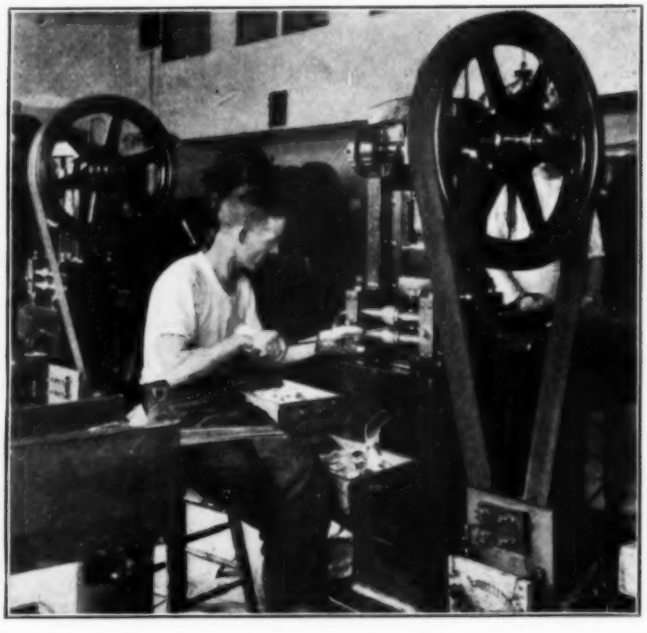


FIG. 4. PUNCHING OUT THE BLANKS

silver alloys are, as already stated, 900 parts pure metal in 1000 of the alloy and if the bars are not of this proportion, they are remelted. The operation of assaying a sample of the gold is accurate, but there is some difficulty encountered in assaying a sample of the silver bars, as the silver and copper in the bars are liable to be streaked. This will cause one part of the bar to be finer than another part, the finer part being in the middle. This tendency to segregation, as it is called, requires some skill on the part of the melter in mixing up his various grades of silver and copper to form a bar which will be just about 900 parts fine in the center from which the metal coins are to be punched.

Between each two processes in passing the metals through the mint, the product of any one department is taken to what is called the transfer weigh room, and here in the presence of a representative of the superintendent and of the departments involved, the metal is carefully and accurately weighed, and the department which is turning out this product is credited with that much weight, while the department receiving it is charged up with an equal amount. The scale readings are carefully observed by the men of the various departments and they agree upon the readings before the material is actually transferred.

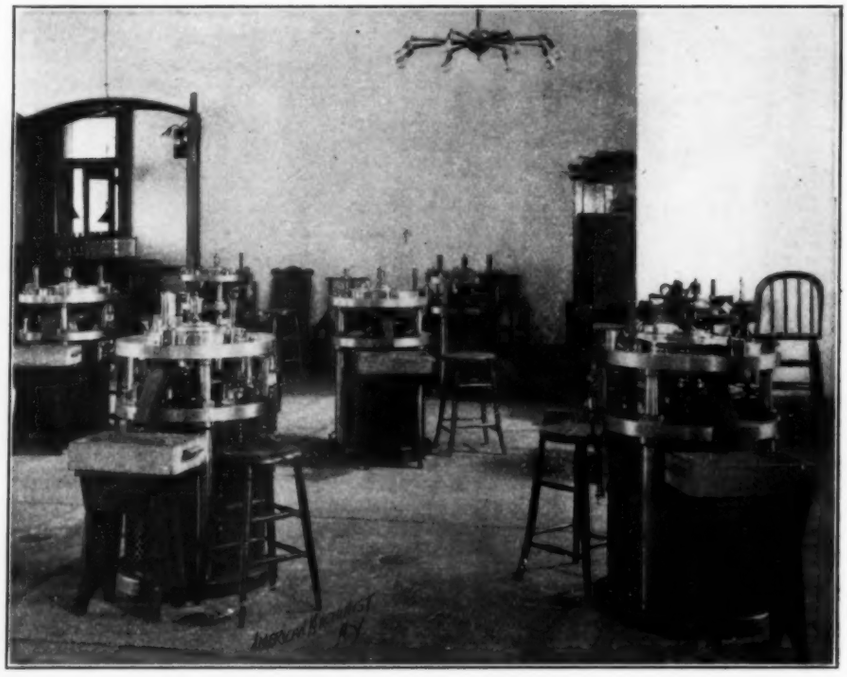


FIG. 6. UPSETTING MACHINES

Rolling

The gold and silver bars are now taken to the rolling room. Here the bars are passed through two sets of rolls, the first being known as the breaking-down or roughing rolls and the others as the finishing rolls. The bars are passed a large number of times through each one of the rolls, being reduced more and more in thickness and growing longer and wider

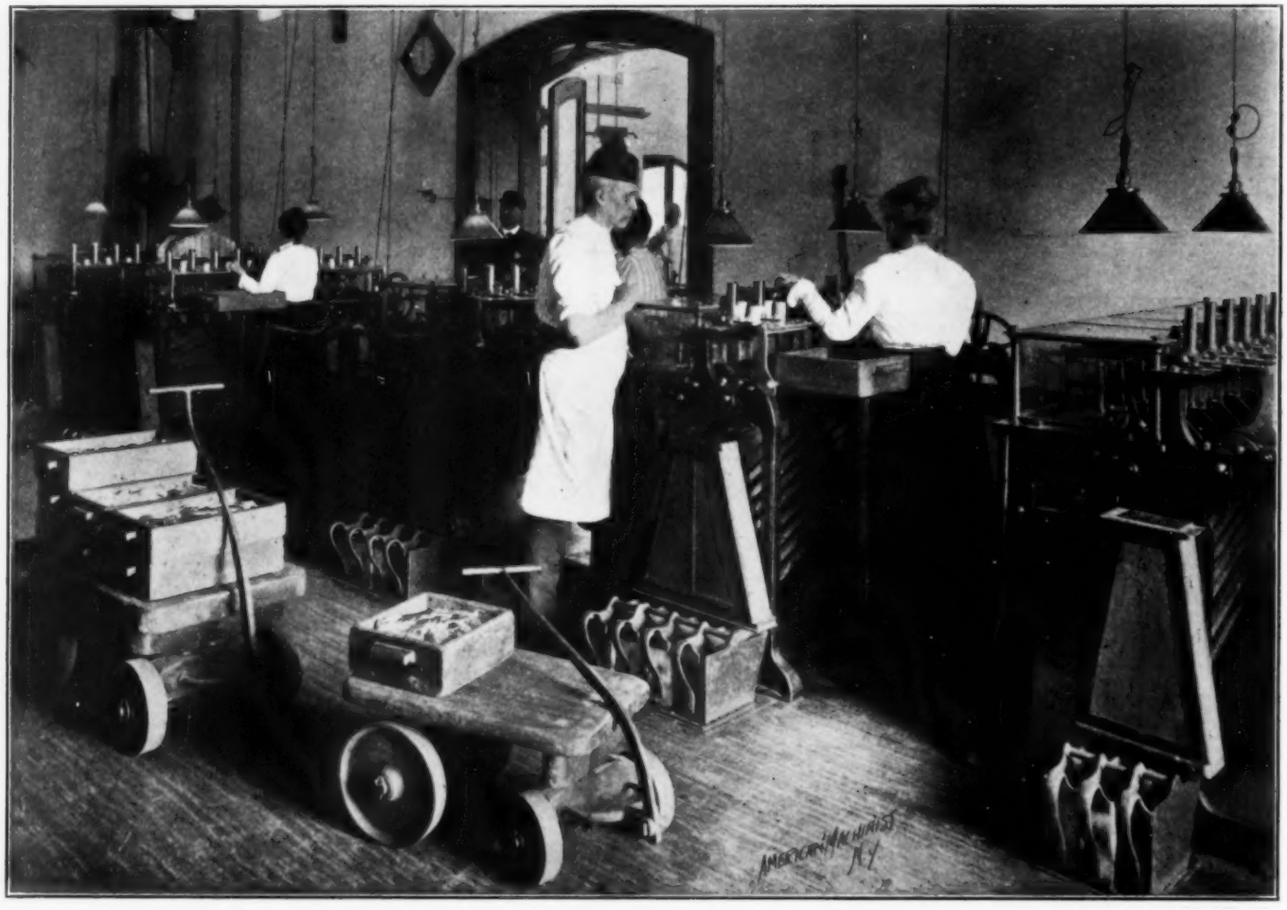


FIG. 5. THE AUTOMATIC WEIGHING AND SORTING MACHINES

with each pass. The adjustment of the rolls is observed by means of a micrometer index on the machine, and these machines are also arranged so that they will immediately stop in case too great a thickness of metal is fed into the rolls, thus preventing the breaking of the machine. At this point it used to be the custom to anneal the strips of metal which are formed by rolling out the bars, but improvements have now been made in the process so that this annealing is not necessary here.

After this punching the metal blanks are very brittle, and it is next necessary to anneal them before any further work can be done upon them. The annealing is done in a gas-fired furnace having spiral guides in its interior and the furnace is caused to rotate slowly, thus traversing the metal disks from the cold to the hot end of the furnace. From the hot end the disks fall into a tank of water underneath. While the sudden chilling would, of course, harden a steel blank, the rolled silver and copper disks are annealed by this process. After the annealing the metal blanks are tumbled in a weak acid solution to brighten them up, and next they are sent to the selecting tables. At the selecting tables the blanks having defects, such as rough edges or flattened sides, are picked out by women who acquire a high degree of skill in rapidly picking out the defective blanks.

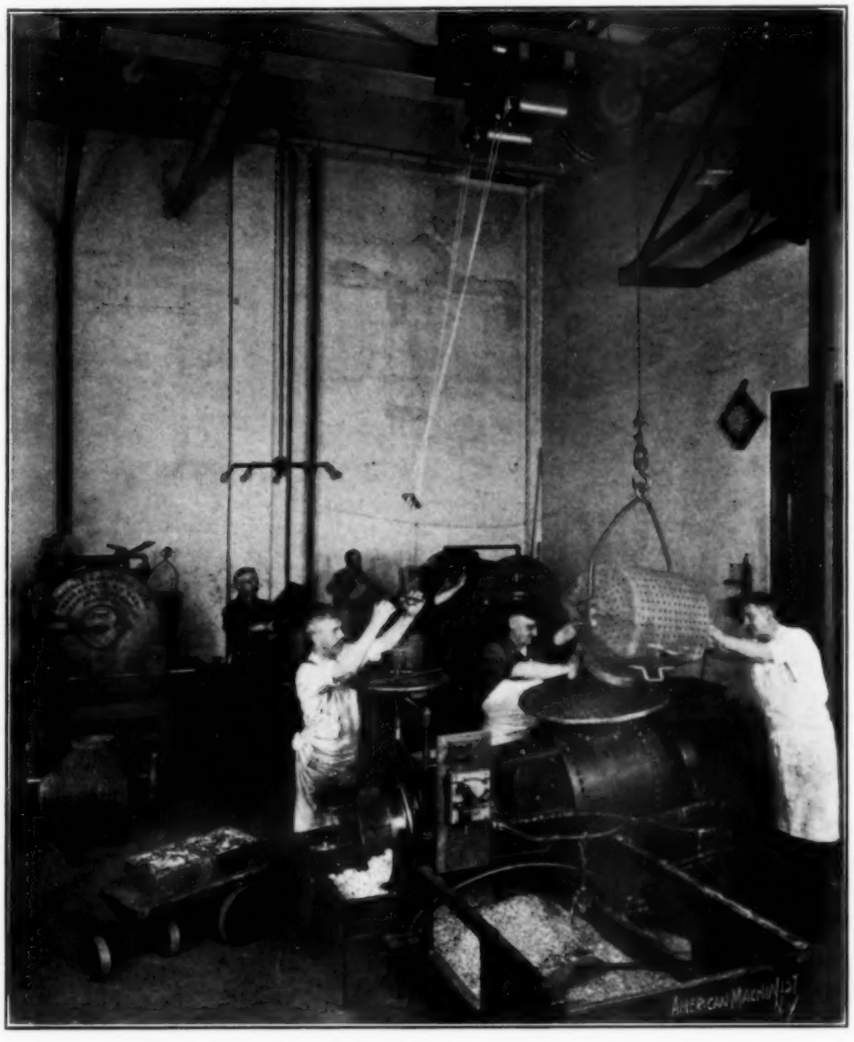


FIG. 7. HANDLING THE BLANKS IN THE WHITENING ROOM

The Punching

The rolled strips of metal are next taken to the punching presses. Here the blank coins are punched from the strips as they pass through, and drop into boxes underneath, the perforated strips being returned to the melter. The money blanks are known as planchets. The rolled strips are made wide enough to cut several coins at a time in their width for the baser metals, the number depending upon the size of the coins. Half dollars are punched in a single row, dimes and quarters are cut in double rows, and pennies are cut in triple rows.

Automatic Sorting

Probably the most important and certainly the most interesting part of an establishment manufacturing money comes next in the process. This is a room where the blanks are automatically weighed and sorted out according to their weight. The coins which are as yet unstamped are fed to the machines through tubes, and from the bottom of these tubes they are dropped one at a time into a small metal basket. According to the weight of the blank, this basket drops down a proportionate distance, and the blanks drop from the basket into tubes, leading to different compartments, each compartment receiving only those blanks having a weight between the predetermined weight limits adopted for that grade. The grades represent those coins which are slightly heavier than the exact standard and those which are slightly light, but each within the limit of variation allowed by the Government. Outside of these, there are those which are too heavy and those which are too light to be included in the classes which are suitable for money. The machines operate to weigh 40 coins per minute when silver dollars are being sorted or 50 half dollars and the accuracy is within a small part of a grain.

After this automatic sorting by weight, all of the blanks are taken in their separate boxes to the adjusting room, and here the blanks are each individually weighed on a very accurate balance, the weighing being done by women. The heavy blanks are slightly filed to reduce their weight to the proper standard and those that are too light are sent back to the melters. To this department also the finished coins are finally brought back and weighed, in order to insure that the entire product of the mint shall be within the allowable standard.

Upsetting

The raised rim which appears on United States coin is for the purpose of protecting the face of the metal, and the stamping thereon. This raised edge is produced in what is known as the upsetting machine. This machine, which receives the blanks in tubes, rolls them between two grooves in a couple of circular plates, one plate revolving inside of the other. This rotation, which, of course, is done under pressure, raises a rim of metal around the edge of the blank coin. After this the blanks are annealed in a rotary annealing furnace, then dipped in a weak solution of sulphuric acid to brighten them, this acid treatment being given in small tumbling barrels. This process is termed whitening.

Stamping

The next step is to transform the blanks having the raised edges into real coin by the stamping of the Government design upon the front and the back of the disk. This work is done in a large room in which there are 25 coining presses. These coining presses are beautifully built pieces of machinery and their general appearance is different from almost every other kind

of press. The main frame is in the shape of a large oval, very heavily built and exceedingly rigid to withstand the great pressure required, which amounts to over 150 tons for some pieces, in stamping the coins. The pressure is applied by means of a toggle joint operated from a cam. All the parts of the presses are kept brilliantly polished, and the appearance of this stamping room is impressive.

The coins are fed by the operators into a short tube on each press, and from the bottom of this tube a pair of fingers draws out one blank at a time, places it under the descending die, and holds it there while the impression is made. The one impression stamps both faces of the coin and furthermore squeezes the metal of the small raised rim out into the edges of the die, forming the so-called milling on the edge of the coin. The raised rim which was on the blank is an aid in the perfect forming of this milling as it is produced simply by the squeezing of the excess of metal into the edges of the die itself, which, of course, is shaped to form the milling. It will be of interest to remark that the milling or reeding, as it is called, on the edge of the coin is to prevent the coin being filed off by persons wishing to obtain precious metals in this manner, without visibly defacing the coin. The stamping is done at a speed of 80 to 100 per minute, depending upon the denominations, there being more of the smaller coins than of the larger ones. The coin is forced up from the lower die after stamping and carried off to one side by the fingers already spoken of, which also deliver the blank coins to the press.

After stamping, the coins are passed out from a hopper onto moving canvas belts, passing before skilled women operators who inspect each individual coin as it passes by. After passing the first inspector, the coins are dropped down by the belt and automatically turned over and passed back the other side up before the second inspector, thus doing away with the necessity for turning the coins over by hand and in this way making it possible to inspect a large number of coins in a short time. There is also a test made for ringing; that is, the coins are dropped one after another on a metal plate, and by the sound given out, the women who do this work detect whether or not the coin is sound mechanically.

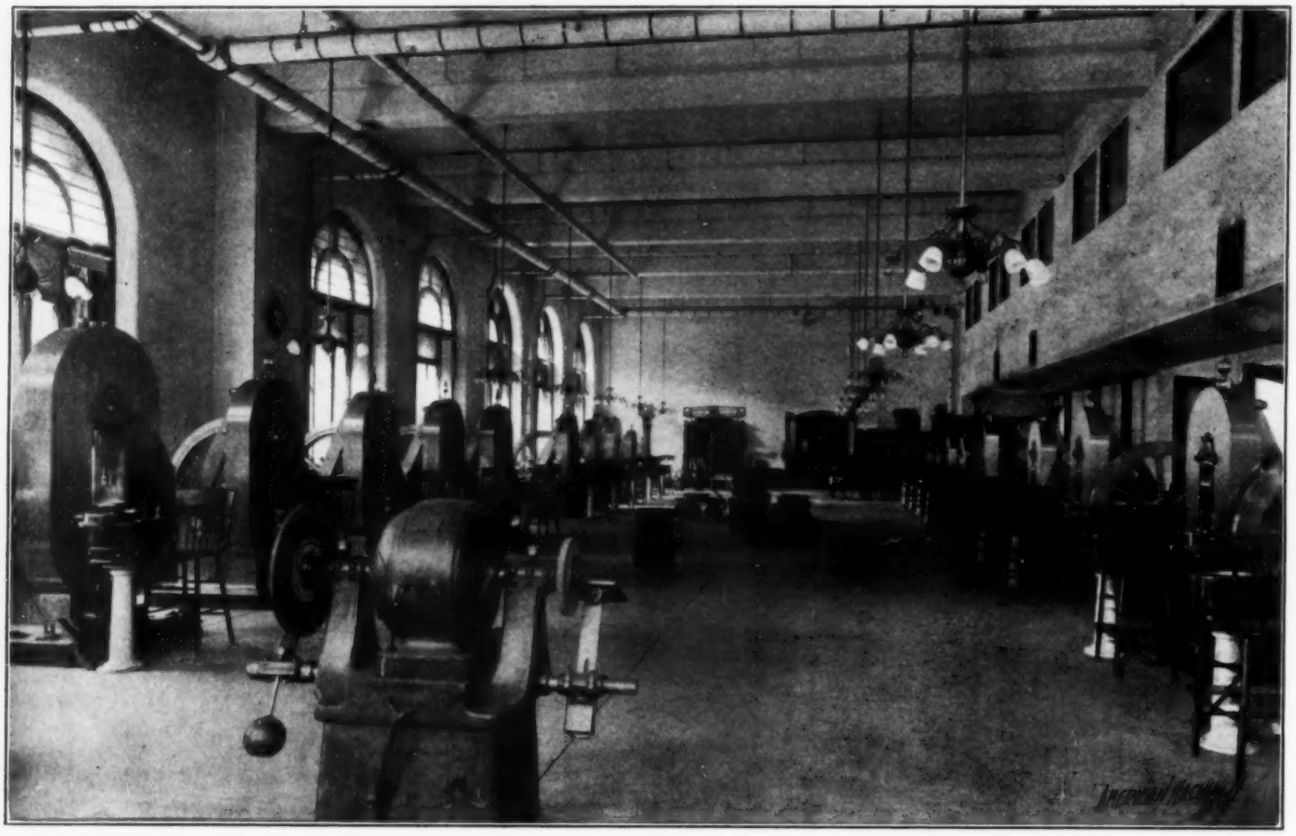


FIG. 8. THE COINING ROOM

Counting

The counting of the coins is one of the most interesting processes. The smaller coins are counted on boards. These boards are divided off into grooves with metal partitions, each groove being wide enough to contain only a single row of coins of a given size. The operators shovel up the coins from the boxes coming from the inspectors and pour them over these counting boards. There is a ridge at one end of the board only just as high as the thickness of one coin, and by tipping up the board, all the coins will slide off into the box underneath, except just enough to fill each row or groove in the board, being held in by the low ridges. Each coin is laid flat on its face, all the coins in any one groove touching each other. When the operator is assured that there is only one thickness of coin layer all over the board, he lifts a small lever which bends down a section of the upper part of the board about 6 inches wide, this section being attached to the main board by hinges. This tipping of the section of the board causes all the extra coins above a certain line to be dropped off into the box underneath, leaving the counting board just exactly full of coins which will contain a large number of pieces at one time, say 500 or 1000, depending upon the denomination of the money, and this number of coins is dumped into a bag held by another operator. The counting of gold and also of silver dollars is done by hand by other operators.

Mixing

It will be remembered that some of the coins made are slightly heavier than standard and others slightly lighter, but each within the allowable variation of weight as set by the Government. Some of the coins, after adjustment will be of

exactly the correct weight and, as already described, these coins of various weights have all been separated or sorted by the automatic weighing machines. In carrying the coins through the process of minting, these different weight coins are all kept separate, and are known as the "standard," the "light" and the "heavy." As the deposits of gold, silver and other metals which are made in the mint are all charged against it and as every particle of metal passing through is weighed between each two stages in its progress, the final output in money must also check up in weight at the end of the process, there being, of course, a very small allowance for absolutely unavoidable loss.

FIG. 9. A COINING PRESS

If shipments of money were made separately from the different weights of money coined, one shipment might contain all heavy coins and another all light coins; so in order that each shipment of coin from the mint shall be of the standard weight for the value represented, a certain number of coins of each weight, that is of any one denomination, are put by an operator into one of the large scales already described. A given number of coins of a certain denomination, if all of standard weight, should, of course, weigh a given amount, and it is the duty of this operator to so adjust the standard, the light and the heavy in the correct proportion, that the total weight of the mixture will be according to standard within one-hundredth part of an ounce. The gold is put up in bags of $5000 each, and silver in bags of $1000 each. These bags of money are the final output of the mint, the total output being about $140,000 per day.

The Sweepings

As it has been several times stated in this article that each department is rigidly charged with the amount of metal which it receives and credited with the amount which it puts out, and that the total amount of metal passing out as coin must equal within a very small fraction the weight of the metal coming in as deposits, and remembering further that the process of minting includes melting, filing, rolling, cutting, stamping and adjusting, it may occur to the reader that there must be considerable loss of metal on the floors of the mint itself. In order to obviate this floor loss, the sweepings from the various parts of the mint are carefully gathered and every night are melted in a crucible for this purpose. At stated intervals also the stacks leading from the melting furnaces are scraped down, and these scrapings are melted. In this way from $12,000 to $15,000 per year are saved from these sweepings. It will be noted by examination of the photograph of the melting room that the floor of this room has a peculiar grid construction. These grids are in the shape of small cast-iron hexagons and these hexagons may be lifted out in hexagonal groups about 10 inches across. This construction allows the small particles of gold, silver and copper to drop down between them, and at night the grids are removed for the sweeping of the floor. This floor construction is confined to the melting room, because it is here that the roughest work is done on the metal, and the particles falling to the floor are liable to be larger than in other parts of the mint where it could only take the form of dust.

In passing through the mint, the Government allows a loss of half an ounce of gold per thousand ounces and one ounce of silver per thousand for abrasion from the coin. The actual number of times that the metal is weighed varies from 15 to 20, the gold being weighed oftener than the silver.

Industrial education in Japan is receiving considerable attention as is shown by a recent report from that country. The industrial schools are established by the central government and by local municipalities and according to the report the Nautical School, Tokyo, had 278 scholars in navigation and 200 in engineering Agriculture and forestry are taught in Morioka, in northwestern Japan, having 29 instructors and 237 students. There are also six higher technical schools, maintained by the government, at different cities, in which are taught dyeing and weaving, furnace work, applied chemistry, mechanics, electricity and industrial designing. Two of the schools teach engineering, mechanical, civil and marine, and in one of the schools a course in electrical engineering is a feature. The Tokyo school has an apprentice school attached. In addition to the above government institutions there were in 1907 over 4000 schools, private and public, dealing with all lines of industry and commerce.

Long Distance Pumping of Natural Gas

An Industry Employing Large Gas Engine Driven Compressing Units, with Some Remarks on Gas Compression under Varying Conditions

BY SNOWDEN B. REDFIELD

In parts of Ohio, Indiana, Pennsylvania, West Virginia, Kansas, Missouri and other States of the Middle West, there are belts of a peculiar kind of soil known as gas sand, from which natural gas may be obtained and piped to localities where it may be used.

The gas in these wells occurs at some pressure usually considerably above the atmosphere, this pressure sometimes amounting to several hundred pounds. In many cases, however, the natural pressure is comparatively low, and for this reason the gas cannot be piped directly to distant towns and cities where it is to be used, because the pressure is not sufficient to deliver the gas through the long pipe lines. To overcome this difficulty, it is customary to install gas-pumping, or compressing plants, these plants usually employing gas engines to drive the compressors. The compressing units are, as a rule, in large sizes, and this gas-pumping industry makes a very considerable field for the large horizontal gas-engine business.

These compression units should really be characterized as boosting units, for their duty is to raise the pressure of the gas from that delivered by the wells to some higher pressure in order to transmit it through long pipe lines to the centers of its distribution. The pressure is seldom carried above 350 pounds, because above this pressure, in cold weather there is considerable trouble from liquid and even solid deposits from the gas. At pressures lower than this, it is still necessary to make provision for draining out the liquid deposits, by placing draining tanks at suitable intervals along the pipe lines.

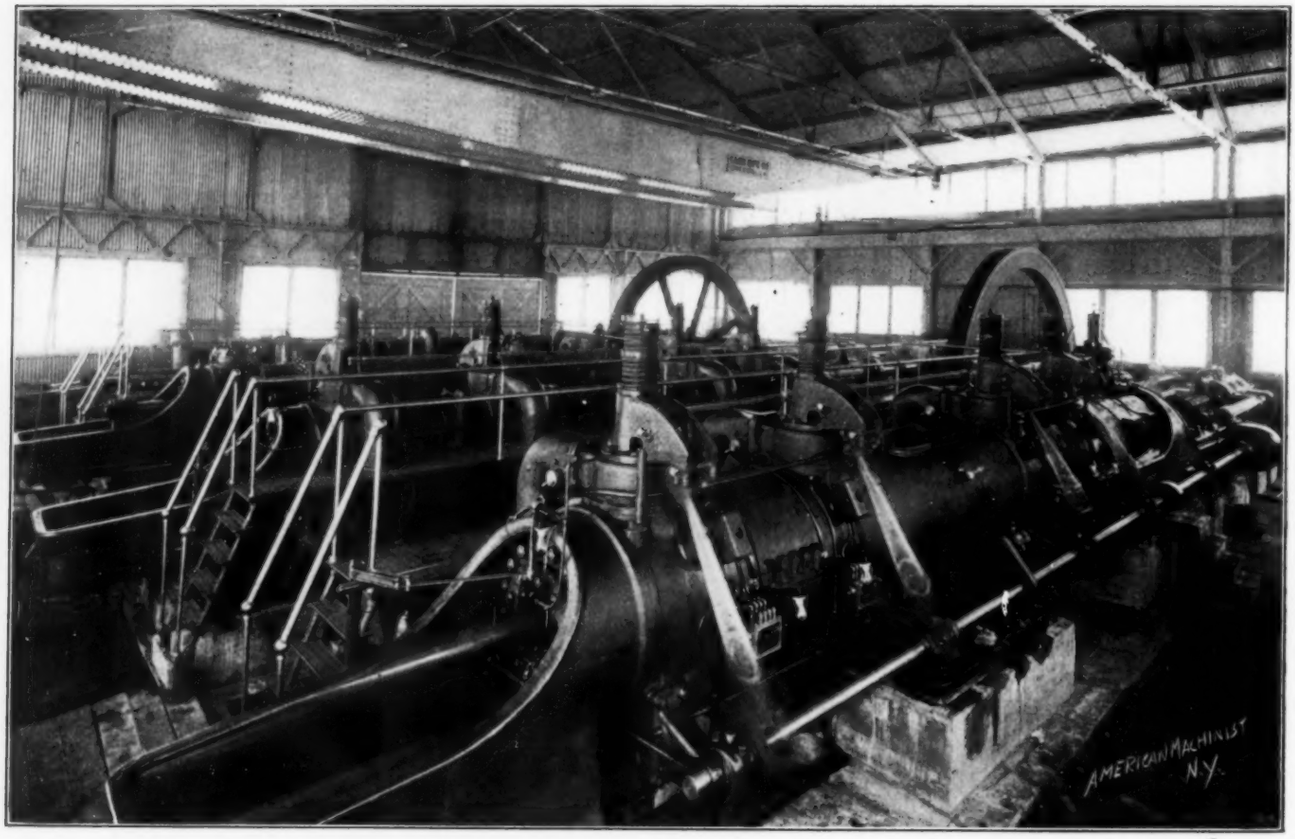


FIG. 1. POWER END OF WESTINGHOUSE, INGERSOLL-RAND NATURAL GAS COMPRESSING UNIT. MOHICAN GAS AND OIL COMPANY, HOWARD, OHIO

The Howard Plant

The photographs reproduced herewith show two direct-connected Westinghouse gas-engine driven units employing Ingersoll-Rand compressing cylinders. These units are installed at the pumping plant of the Mohican Gas and Oil Company, at Howard, O. The rating of the engines is about 1300 brake horsepower at 88 revolutions per minute. The engine cylinders are 23½ inches in diameter by 48-inch stroke, and at the maximum speed of 88 revolutions per minute, this gives a piston speed of 704 feet per minute. The compressing cylinders are 18⅝ inches in diameter by 48-inch stroke, giving a piston displacement of 2410 cubic feet per minute at full speed.

The gas which is pumped or boosted by these units comes from about 100 gas wells located all through the country within a radius of probably 35 miles from the pumping station. The wells are, as a rule, from 2600 to 2800 feet deep, and the gas is brought to the pumping station in pipes of varying sizes from 6 to 10 inches in diameter.

The pressure of the gas by the time it reaches the pumping station when delivering the normal quantity is about 70 pounds, this pressure being adjusted according to the demand, by telephone connection to men in the field, who

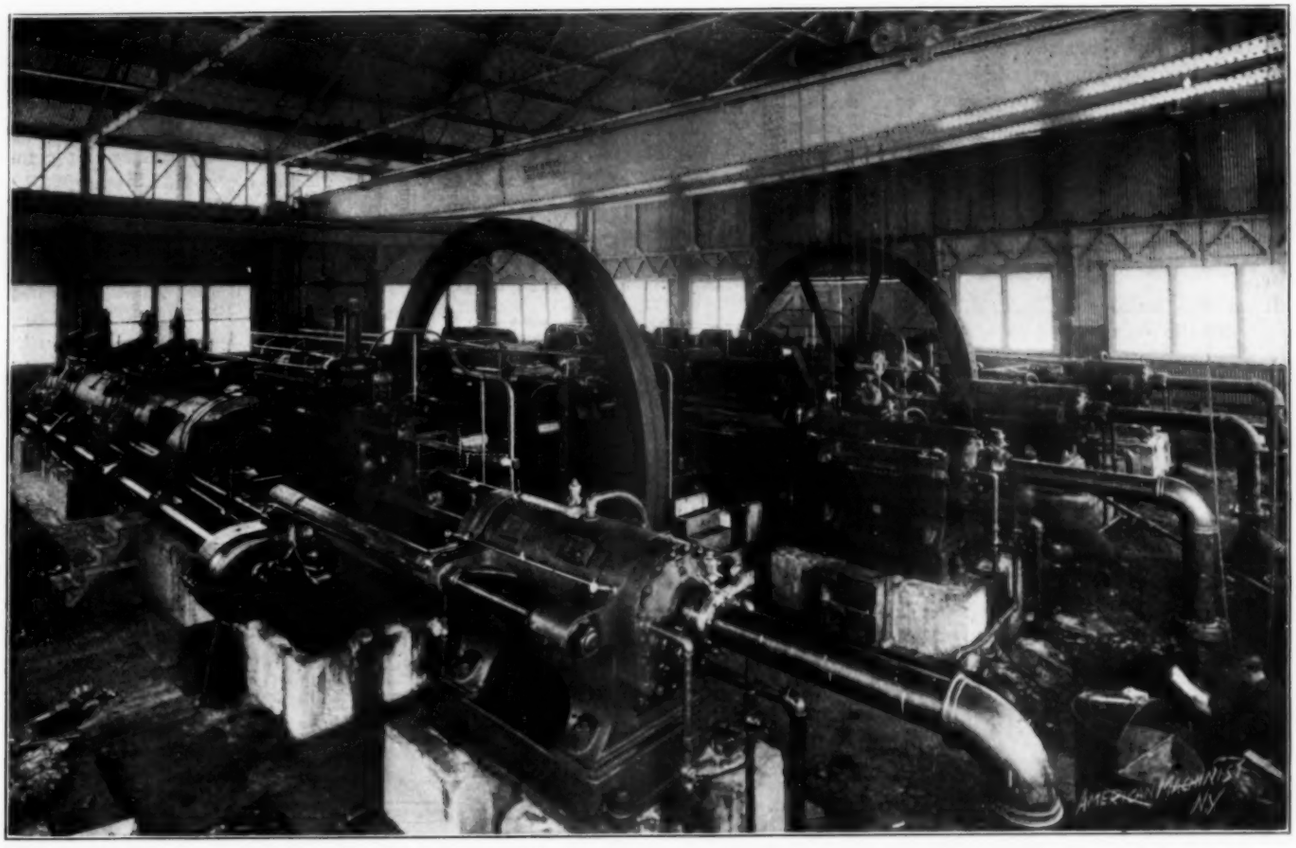


FIG. 2. COMPRESSING END OF WESTINGHOUSE, INGERSOLL-RAND COMPRESSORS

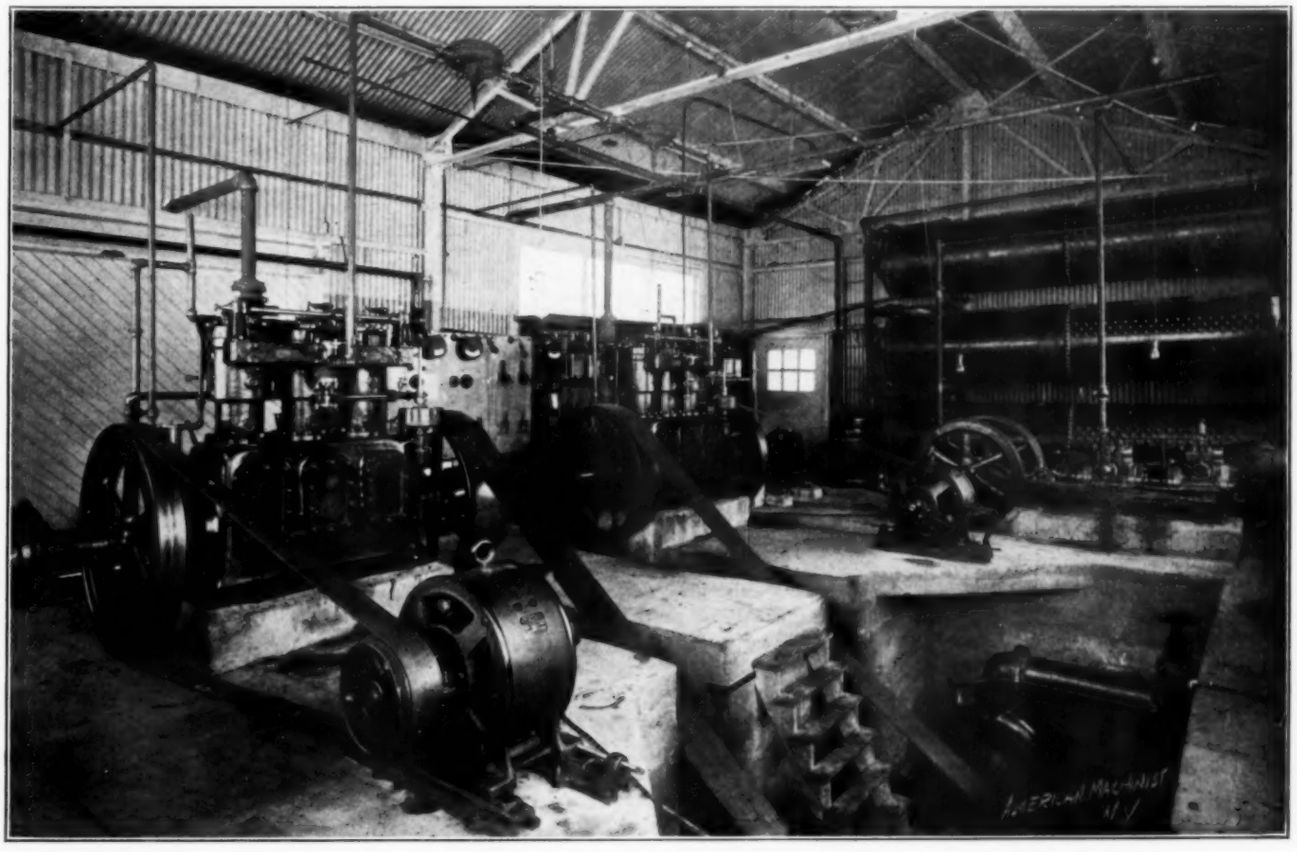


FIG. 3. AUXILIARY ROOM, MCHICAN GAS AND OIL COMPANY

manipulate the valves at the wells, as desired. At present the compressors are raising this pressure to about 185 pounds at the station and delivering it through 10-, 12- and 16-inch pipes extending about 80 miles from the station, and furnishing about 100 pounds pressure at the far end. This gas is delivered at Akron, Barberton, Orrville, Millersburg, Wooster and intermediate towns in Ohio, where it is used for every domestic purpose.

It is the custom of gas companies to pay for the gas obtained from the wells by givng a royalty of so much per year to the farmers on whose property the wells are located, this royalty being based upon the acreage of the land owned by the farmer.

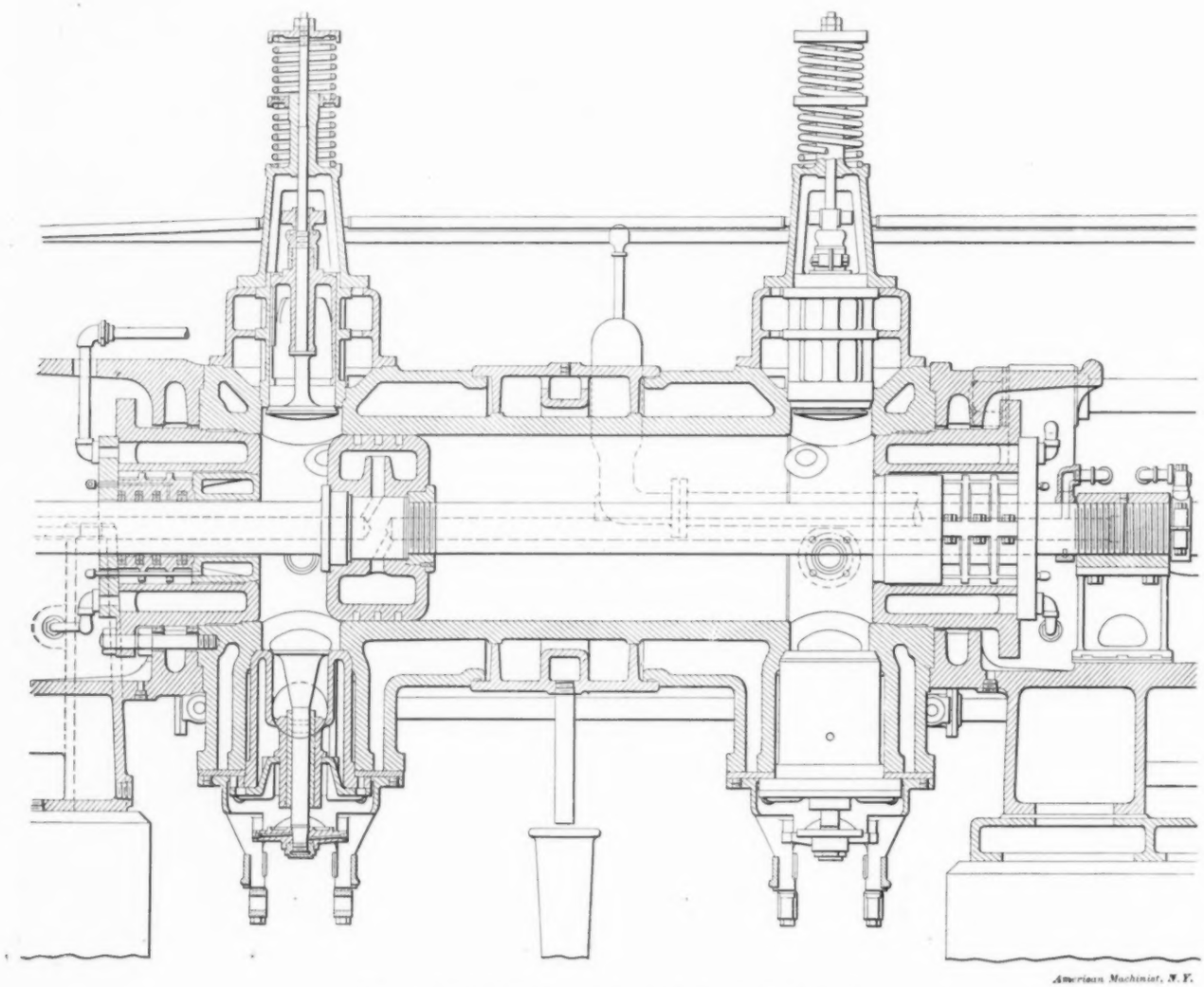
The gas engines at the Howard plant are of the well-known Westinghouse horizontal, double-acting, four-cylinder, four-cycle type. By this construction, there being one impulse in each end of each cylinder at every other revolution, there are as many working impulses in one revolution as would be obtained from a two-cylinder steam engine, and the smooth action of the engine is very like that of a steam-driven machine of equal size. The inlet valves to the engine cylinders are seen in the photographs to be located on the upper side. The exhaust valves are underneath. Both the inlet and exhaust valves are operated by eccentrics working on rocking cams, this construction being used to insure smooth operation and freedom from shock and vibration. The exhaust valves and cages, as well as the cylinders, are water-jacketed.

The governing of the engine is done by the rotation of grid openings in sleeves located in the inlet-valve chambers. The rotation of the grid sleeves themselves is accomplished by reach rods and levers operated by a plunger. The plunger is moved by oil under considerable pressure, the oil being controlled by a pilot valve, which latter is under the direct influence of the revolving governor balls. In this way the operation of the governing valves is not produced directly by the action of the centrifugal force on the revolving balls, and thus its sensitiveness does not depend upon the degree of friction that there may be in the various levers and rods.

The igniters are of the magnetically operated type, that is, the electric contacts inside the cylinders are made and broken by an electromagnet outside of the cylinder and controlled by an electric commutator on the lay shaft. Fig. 4 shows a cross section of the engine cylinder.

The Compressing Cylinders

The Ingersoll-Rand gas-compressing cylinders are shown in Fig. 2. These gas-compressing cylinders employ the well-known "Hurricane" piston inlet valves manufactured by the company furnishing these cylinders. The inlet valves themselves are located on the faces of the gas-compressing piston, which latter is hollow. The valves are circular in shape and the cross section of the ring is that of a letter T with the flat side serving to cover the circular port in the piston. There are no valve springs and it is claimed that the valve is opened and closed mainly by its inertia caused by the stopping and starting of the piston at the end of each stroke, that is, when the pis-



American Machinist, N.Y.

FIG. 4. LONGITUDINAL SECTION OF GAS-ENGINE CYLINDER

ton comes to rest at the end of its stroke, the valves, due to their weight naturally tend to continue their travel, and the motion thus imparted to them is said to throw one valve shut and the other one open, ready for the next compression stroke.

In this way there are supposed to be no losses by friction or wire drawing of the gas or air entering the compression cylinder, as would be the case if ordinary spring poppet valves were used. Furthermore, it is usually considered that a Corliss valve is not suitable for the compression of natural gas, because the impurities in the gas tend to rapidly wear out the valves and their seats, soon rendering them unfit for use.

The discharge valves in the compressing cylinders are of the ordinary poppet type with springs, and they have the additional feature that, when they are thrown open by the action of the compressed air or gas passing out of the cylinder, the trapping of a small quantity of air or gas in a space between the valve and the cap tends to prevent the valve from striking the cap. The object of this is to make the valves as quiet running as possible and also to prevent the breaking of the valve due to the heavy shock of opening. The compressing cylinders are, of course, completely water-jacketed.

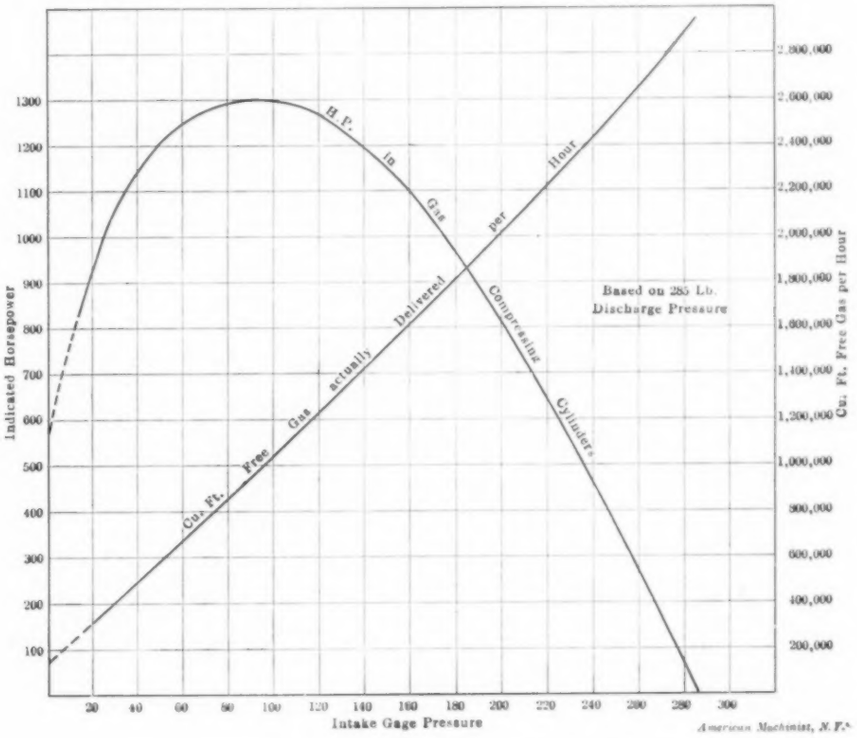

H. P. in Gas per Hour
Cu. Ft. Free Gas actually Delivered
Compressing Cylinders
Based on 285 Lb. Discharge Pressure
Indicated Horsepower
Cu. Ft. Free Gas per Hour
Intake Gage Pressure
American Machinist, N. Y.

FIG. 5. HORSEPOWER, CAPACITY CURVES, COMPRESSING NATURAL GAS

The Auxiliaries

Fig. 3 is a photograph of the auxiliary room of the Mohican company, at Howard. This auxiliary station contains two 45-horsepower three-cylinder Westinghouse vertical gas engines, driving electric generators and centrifugal pumps. The generators furnish the electric current for lighting the plant and also for the ignition of the engines. The centrifugal pumps furnish the circulating water for the cooling of the engine and compressor cylinders. In connection with the ignition it should be said that in the auxiliary station there is a bank of storage batteries floating on the electric line, furnishing current to the igniters, so that in case of the stopping of the auxiliary engine due to any cause, the current for the ignition will flow from the batteries to the main engines, and these will not necessarily stop, due to the temporary interruption of the current from the generators.

The auxiliary engines are also arranged to drive small air compressors which furnish air at about 175 pounds pressure, which is stored in the tanks shown in the photograph, Fig. 3. This air is used for starting the main engine, and this operation is a very simple one, involving only the throwing of a lever to bring into play special cam-operated air valves leading to each gas-engine cylinder to give it an impulse for the purpose of starting the engine.

After compression at the Howard station the gas is passed through a system of piping completely submerged in water. This is to cool the gas and to precipitate the moisture, and as much of the liquid and solid deposits in the gas as possible before passing out into the long pipe lines. The pipe lines are made of special stocks, known as "plain-end" pipe, and the couplings employ a rubber gasket and also provide for expansion and contraction with temperature.

The Power Required

As has already been said, natural gas usually occurs at pressures considerably above the atmosphere, and in the design of a gas compressor special attention must be paid to this, because the power required to deliver gas to any particular final discharge pressure depends very greatly upon the pressure of the gas delivered to the compressing cylinders. Fig. 5 shows two curves, one of these being the indicated horsepower developed in the gas-compressing cylinders of the Mohican machine, and the other the cubic feet of free gas actually delivered per hour. The horsepower curve is figured on a basis of 285 pounds discharge pressure which is the figure for which the units were designed for future use. In both these curves the intake pressure is supposed to vary from atmosphere all the way up to 285 pounds, and it is seen that when the intake pressure is about 90 pounds gage, with 285 pounds discharge, the horsepower developed in the compressing cylinders is a maximum. When the intake pressure is either below or above this point, the horsepower is less than it is at this maximum point. Due to this wide variation of power required, it is clear that the gas-compressing unit must be designed for the maximum power which it may be called upon to develop at some future time as the well pressure changes.

The power conditions will very seldom remain anywhere near constant, because with the continued pumping of the gas as the years go on, the pressure is gradually reduced, and if it should happen that the initial conditions are such that the intake pressure given by the wells is above that pressure which would give the maximum horsepower there will be a considerable period during which the horsepower will be increasing from day to day as the intake pressure to the compressor becomes lower. After the maximum horsepower point has been reached, this power will again begin to decrease and will so continue as the pumping is continued.

While the horsepower has thus been changing, having passed through a maximum, the actual quantity of gas delivered by the compressing units has also been changing, but this change involves only a decrease in the output, as shown by the diagram. The actual quantity of gas compressed is directly proportional to the absolute intake pressure to the compressor, and for this reason it is clear that as the intake pressure is decreased, the quantity of gas passing through the compressor is also decreased, and this is independent of the discharge pressure.

Compression Efficiencies

While the intake pressure is decreasing there are other changes taking place in

the compressing cylinders which it is important to note. These changes are in connection with the volumetric efficiency and the efficiency of compression. The volumetric efficiency, as its name implies, means the actual quantity of gas delivered by the compressing cylinders, referred to the piston displacement of the cylinders. The efficiency of compression means the ratio of the theoretical power which should be required to compress a given quantity of gas through the specific range of pressures, to the actual power developed in the compressor cylinders.

The volumetric efficiency depends very largely upon the area of the inlet valves and the volume of the clearance in the cylinders. The effect of clearance is to trap a portion of the gas in the clearance space, this gas reëxpanding at the beginning of the suction stroke, delaying the opening of the inlet valve and preventing the complete filling of the cylinder with fresh gas. The loss of efficiency of compression is caused by lack of valve area and is represented by excess of indicator-card area below the intake line and above the discharge line. It is really the loss of power by the forcing of the gas into and out of the cylinder.

Now as the intake pressure begins to decrease with a fixed discharge pressure and the discharge pressure is, of course, increasing. In other words, the ratio of compression is increasing. With increase in the ratio of compression should come increase in efficiency of compression. This is due to the fact that the gas being compressed a greater number of times with an equal valve area, and also there being less gas handled as the intake pressure decreases, the area of excess work shown on the indicator card should bear a smaller percentage to the total area of the card.

The increase in the ratio of compression will also increase the amount of gas which is trapped in the clearance spaces, and which reëxpands at the beginning of the suction stroke, thus decreasing the volumetric efficiency as the ratio of compression increases, due to the drop in the intake pressure. In this way the actual output of the cylinder does depend to a slight degree upon the discharge pressure. Of course, the increase in the efficiency of compression is an advantage, as it means a saving of power, but the decrease in volumetric efficiency, while this also proportionately decreases the power, is a disadvantage, because it means that less and less gas is being actually compressed as the intake pressure grows less, by cylinders of a given size costing a certain amount of money to purchase, and this decrease in capacity is in addition to the decrease due to the drop in intake pressure, which latter is, of course, no fault of the compressor itself. The curves plotted in Fig. 5 take into account these changes in volumetric efficiency and efficiency of compression, and in this respect approach more nearly actual conditions than what would be derived from the theoretical formulas.

All these points are of great importance in buying a compressing unit, and should not be lost sight of, due to the seemingly greater importance of the many features of gas-engine construction and operation, as set forth by various designers, for while the engine is by far the more expensive part of the unit, the power developed in the engine is actually absorbed in the comparatively small compressing cylinders, and the efficiency of their performance is as important a matter as the efficiency of the development of the power in the engine itself.

Journal Loads in Geared Mechanisms

By John Edgar

In machines, such as the modern machine tool, in which so much dependence is placed on geared devices for the various speed changes, it has become necessary to so design the various details that the greatest number of parts can be crowded into a limited space. Following this desire for compactness many designs are turned out in which insufficient care has been taken in the allowance of bearing area to sustain properly the loads that are imposed upon the bearings and journals. This objectionable feature is probably due to a misconception of the loads.

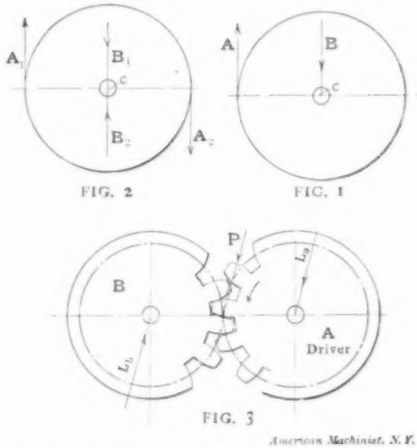


FIG. 2 FIG. 1

FIG. 3

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DIAGRAMS ILLUSTRATING JOURNAL PRESSURES OF GEAR DRIVES

In the new machines in which positive drives are employed, conditions are different from those of the older designs where we used the narrow, slipping feed belt and the narrow, low-speed driving belt. We can now calculate, within very close limits, what load a given journal must carry. Not only is this condition met in the machine tool, but also in the modern automobile, in which we find a geared transmission mechanism with gears worked down to the narrowest limits that can be employed and endure for a reasonable length of time. Compactness and lightness are the main points in automobile design, after a certain standard of strength has been established.

It is the general theory that the gear-tooth pressure is transmitted directly to the journal bearings in inverse proportion to their distance from the gear. While this theory is correct it is not sufficiently broad to cover all conditions that may occur. It is the purpose of this article to point out modifications that must be made in the general theory. This will be done by taking, as examples, different geared arrangements such as are met with in practice.

The function of the gear is to transmit rotary motion, and in so doing must overcome any resistance to motion that may exist.

A force, Fig. 1, acting at the periphery, as A would have no tendency to cause a rotation of the disk unless met with a resistance to motion of the body in a direction parallel with its course. Such a condition is not met with in this material world; even should there be no mechanical resistance to motion we still have that of gravity, and the inertia of the body itself. In this article we will neglect gravity as a load; in most cases it is a very small percentage of the actual working load. Therefore, in Fig. 1, we consider the disk to be journaled at C. Then the force A is resisted at the journal by an equal and opposite force B, which represents the pressure with which the bearing reacts on the journal. These two forces, or force and resistance, tend to rotate the body.

Add at a point diametrically opposite, another force equal and opposite to force A. This force will have a tendency to cause a rotation in the same direction as does the force A. Thus, in Fig. 2, let A_1 and A_2 be the two forces; each force will be resisted by an equal and opposite force at the journal. These resisting forces are B_1 and B_2, which on account of this common point of application and the fact that they are equal opposing forces have a resultant equal to zero. So that in this case we have a body acted upon by more than one turning force with no load being imposed on the bearings, other than the force of gravity. This case is that of a motor, running idle, in which the torque consists of several equal turning forces equally spaced around the periphery.

Fig. 1 represents the case of the motor when transmitting motion through a gear on the armature shaft.

Figs. 1 and 2 may be taken as the two fundamental cases upon which this article is based, Fig. 1 being the one of more importance, and Fig. 2 really a modification.

As a simple application of the principle we have the two-gear train in Fig. 3.

Here, and in what follows, the force is on a 15-degree angle with a tangent to the pitch line at the pitch point, which, of course, is the pressure line of standard gear teeth as commonly used. Here A is the driver and rotates in the direction of the arrow; the pressure transmitted from tooth to tooth is in the direction of and along the line P. Also P is of length representing the magnitude of the turning force. What is required is to find the loads on the journals of A and B. In this article the journal load is taken to be that force which must act at the center of rotation of a body to balance the turning force P. In the driver this force acts parallel to and in the same direction as the turning force P. Thus, in Fig. 3, this force or load on the journal of A is represented by L_a. In the driven gear this journal load is parallel to and acts in a direction opposite to the turning force P and is equal to P in magnitude.

The conditions of Fig. 3 are only met in cases where A and B are connected to shafts that receive their motion from turning forces equally applied, as in Fig. 2; a concrete illustration of which would be a motor-generator set in which the two units were geared together.

The first modification of the case in Fig. 3 is shown in Fig. 4, which is a three-gear train, in which A is the driver, B an intermediate, C the driven gear. Here P_1 is the turning force that is transmitted from A to B, and P_2 is the turning force that is transmitted from B to C. The

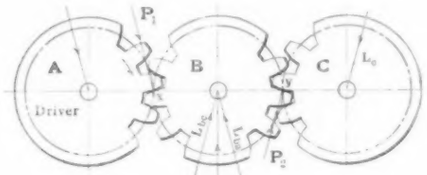

FIG. 4

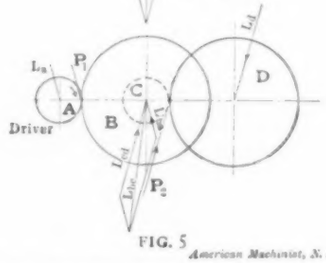

FIG. 5 *American Machinist, N. Y.*

DIAGRAMS ILLUSTRATING JOURNAL PRESSURES OF GEARED DRIVES

rules for driver and driven gear apply in this case so that L_a is the load on the journal of A, L_c is the load on the journal of C. The journal of B must withstand a double loading in this case L_{ba} from force P_1 and L_{bc} from force P_2, as these loads act with an included angle of 30 degrees, the resultant is not quite equal to the sum of the two, but is found by the parallelogram of forces to be L_b. So we see that when a gear is used as an intermediate the journal load is greater than when used direct. This fact is one that should be kept in mind in designing mechanisms in which intermediates are used, so that an insufficient bearing on an overhanging stud will not be used. Intermediates on the overhanging studs may be stated as failures in nine cases out of ten where the work is in the least heavy and are then sure to stick or cramp in the teeth. The same conditions are found no matter how many intermediates may be used, the journal load on each will be the same and equal to practically double the gear-tooth pressure regardless of the diameter.

A modification of Fig. 4 is seen in Fig. 5, which shows a compounded intermediate; A is the driver, B and C the inter-

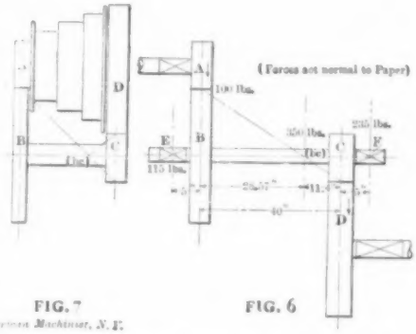

FIG. 7 FIG. 6 *American Machinist, N. Y.*

TYPICAL ARRANGEMENTS OF GEARED DRIVES

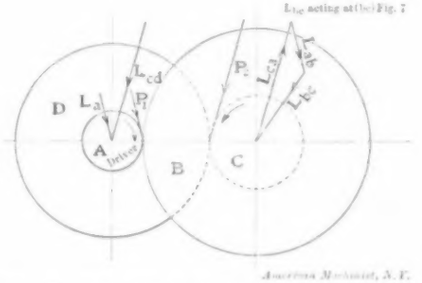

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FIG. 8. DIAGRAM ILLUSTRATING A COMMON ARRANGEMENT OF GEARED DRIVE

mediates and D the driven gear. Here L_a is the journal load of A; L_d the journal load of D; B and C are fixed to the same stud and are taken as one, the journal load being L_{ba} due to force P_1 and L_{bd} due to force P_2, which may be combined into the single resultant L_{bc} by aid of the parallelogram of forces. Here, due to the difference between the magnitude of forces P_1 and P_2 the load on journal of B and C is deflected to one side of the vertical.

In trains in which the intermediate is used it is possible to reduce the journal load to a minimum by setting the intermediate off the line intersecting the axis of the driving and driven gears. This course should be followed as much as possible in all designs embodying this type of gear train.

In Figs. 3 and 4 the journal loads given all act through the midplane of the gear and the load on the journals situated either side of the gear will be inversely proportional to their distance from the mid plane. If the bearings are situated at an equal distance each side of the gear, each journal receives one-half the total load.

In the case of the compounded intermediate in Fig. 5, conditions are different. The load L_{bc} acts not at the mid planes of the gears, but at an intermediate point

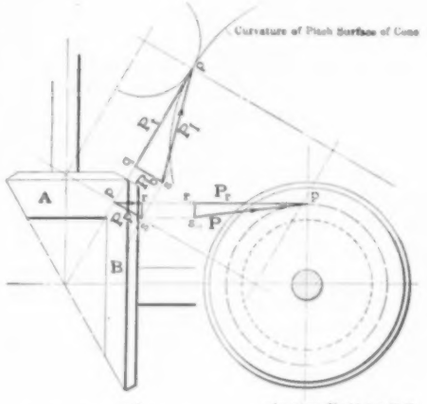

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FIG. 9. DIAGRAM OF A BEVEL-GEARED DRIVE

between these planes. The load on the journal at each plane is not L_{cd} or L_{ba} for gears C and B, respectively, but the load at each gear is modified by the load at the other.

The point of application of the resultant load may be located by the construction shown in Fig. 6. This is a plan view of Fig. 5, and the point of application of the resultant load is found by drawing a line from the mid plane of B at the pitch point in contact with A to the pitch point of C in contact with D at the mid plane. The point of application will be at the intersection of the line just drawn and the center line of the intermediate shaft.

In order to prove this construction let us calculate the journal loads on the two bearings E and F. For the sake of simplicity consider that the forces P_1 and P_2 are tangent to the pitch circles of the gears and equal to 100 and 250 pounds, respectively. Figuring the moments about E to obtain the load at F we get 235 pounds, and that at

$$E = 350 - 235 = 115 \text{ pounds.}$$

Now the position of the point of application, bc, of the resultant which is, when the forces P_1 and P_2 are taken tangent to the pitch circles, the sum of the forces at the gear teeth can be found by proportion. Its distance from the mid plane of either gear is proportional to the radius of the gear; this brings it 28.57 inches from mid plane of gear B and 11.43 inches from that of gear C. The moment about E using the load concentrated at bc must necessarily equal the moment about E of the load on the journal F, from which we have, load on $F \times 50 = 350 \times 33.57$,

or load on $F = 235$ pounds, which is the same load as found by the method above. This proves our contention to be right.

Fig. 7 shows a familiar arrangement of gears—the cone and back-gear arrangement—and we can find the point of application $b\,c$ of the resultant of the thrusts of A and C by a similar construction. The magnitude of the resultant is found by the parallelogram of forces from the two thrusts on the bearing due to P_1 and P_2, in Fig. 8. In this case the resultant load is less than the larger of the two gear thrusts. The load L_w is the load against the internal surface of the quill.

A different way of looking at the question is to consider the gear a simple lever, the fulcrum being at the pitch point in contact with the driven gear and the point of application of power at the pitch point in mesh with the driver. The journal will represent the weight pans. Thus in Fig. 4, joint x is the point of application of the power, the diameter $x\,y$ is the length of the power arm and the length of the weight arm is consequently the radius of the gear B and the upward load on the journal, in order to have the imaginary lever in equilibrium, is the resultant of the reaction of force P_1 and the reaction P_2 at the fulcrum y, which is L_b. In this case, since the force and reaction act in an oblique direction of similar angles from a common reference plane the load at the journal is the algebraic sum of the components of the force P_1 and reaction P_2 tangent to the pitch line; the normal components neutralize each other.

When working on this plan it should be remembered that the reaction at the fulcrum of a lever is equal to the algebraic sum of the force and weight. Thus, in Fig. 4, the sum of force and weight is P_2.

Take the more complicated case of Fig. 8, the force arm of the imaginary lever is proportional to the difference between the radius of B and C; the pitch point of C in mesh with D is the fulcrum; P_2 is the load at the fulcrum. The force that keeps the lever in equilibrium is the reaction of the force P_2. In order that the lever may be in equilibrium the forces must have the same value as the reaction, therefore, the force at the end of the power arm and the force at the end of the weight arm must be algebraically equal to P_2; we know what P_1 is, so P_2 may be resolved into components of which P_1 is one and L_w is the other.

The fulcrum of a lever is always a point of reaction, so in gear trains the reacting point at the pitch point of a gear, where it meshes with the driven gear, may be considered the fulcrum of a power lever, which it really is, and is held in equilibrium so that a turning motion is effected about the axis of the gear, which is the applying point of the weight or load. This may be clearer if we imagine that the gears B and C are not held in restraint by a bearing at their axis; a force applied at the point of application P_1 would then cause the gear C to climb up around the gear D.

Bevel-gear Trains

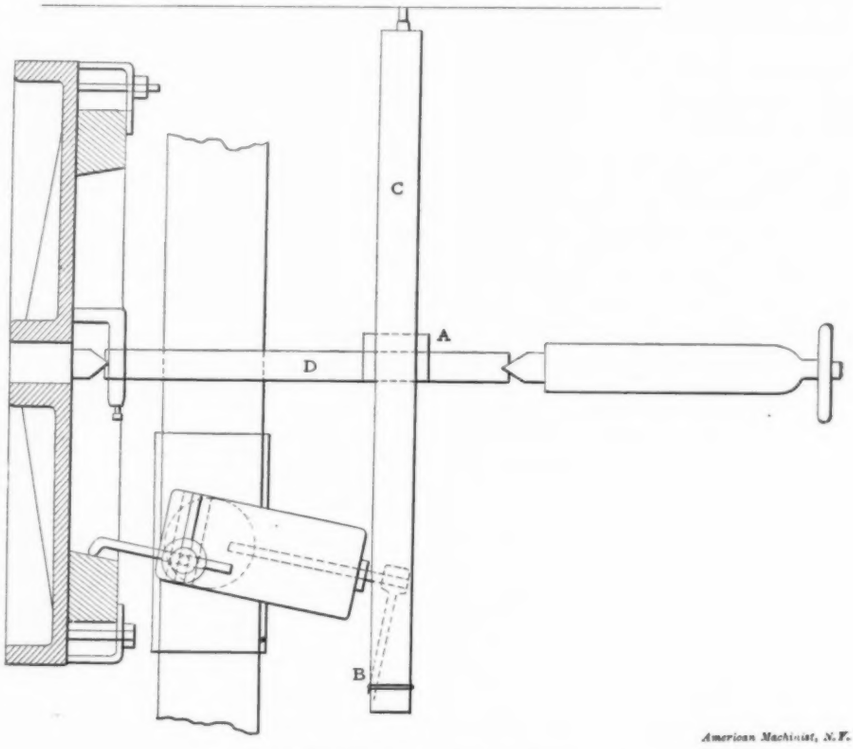
Bevel-gear trains may be treated in a similar manner to the above treatment for spur gears. The turning forces and reactions may be divided into a component tangent with the pitch cone at a point midway along the tooth face or, if the gears are cut by the formed tooth process, probably it would be better to take the force at the large diameter of the pitch cone, as these gears usually bear mostly at that point. The other component would be parallel with the axis of the gear and is the thrust of the gear against the end of the bearing. Fig. 9 shows this applied to a right-angle drive. Here p is the pitch point and the point of application of the turning force P_1. P_1 is resolved into the components P_t tangent to the pitch circle and P_p perpendicular to the tangent, or normal to the pitch circle at the point p. Here P_p is projected to the position P_{p_1} and is resolved into right-angle components pr and rs, which are the thrust of gears A and B, respectively, against the ends of the bearings. We then project $r\,s$, to $r_1\,s_1$ at a distance from the point p equal to the magnitude of P_t, joining s_1 and p we obtain the force P_{11} at the pitch point p. This P_{11} is the force used in applying the foregoing principles in connection with bevel-gear trains. They are as easily applied in the case of bevel-gear trains as with the spur gears.

An Improvised Automatic Feed for the Compound Rest

By Wallace C. Dixon

Some time ago I was given the job of boring a number of chills for car wheels on a lathe which had neither taper attachment nor automatic feed for the compound rest.

Not liking the task of feeding the cuts through by hand, I hit upon the following scheme: I took a piece of pipe A about 5 inches long and wedged it on an old boring bar D about 2½ inches in diameter. I then attached a dog to the bar D and put it between the centers. A piece of plank C was hinged to a shelf behind the lathe. This plank extended out over the piece of pipe A, which acted as an eccentric. The plank was connected at B to a ratchet handle which operated the feed screw. By changing the position of the rope connection along the plank or ratchet handle I could vary the feed, giving from one to four teeth of the ratchet, each revolution. While this method of tapering could only be used in very large holes, it served its purpose well, and required only about ten minutes time to rig up.



AN IMPROVISED AUTOMATIC FEED

Experiments in abrasion conducted at a French mint have proved that aluminum coins will be less rapidly worn by use than coins made of gold, silver, or even bronze.

Practical Letters from Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

A Portable Countersinking Device

The accompanying line engravings illustrate an arrangement for countersinking holes at the inside of suction tubes. These tubes, which form part of a paper machine, are made in various lengths and diameters and the periphery is perforated with thousands of small holes, through which water and refuse pass. To prevent the refuse from adhering to the edges of the holes, it is found necessary to countersink them at both ends, a feat not only difficult, but expensive when accomplished inside of the tube.

The internal countersinking is done in various ways by the paper-machine builders, and two of these methods are illustrated in the drawings.

In Figs. 1 and 2 can be seen a device produced to overcome the objections found in the one shown in Fig. 3; the difference in these two devices lies in the method employed in moving the countersink from hole to hole within the tube. The device shown in Figs. 1 and 2 has a centering frame *A* which slides on the two shafts *B* and *C* and has inclosed within it two miter gears *D*, two bushings *E* and *F* and the casting *G*, while protruding from the lower section of this frame are two arms *H* which support the two rolls *I*. At the top of the frame are two more rolls *J*, which can be adjusted up or down to fit the various sizes of tube within a certain range, while for sizes above that new fingers *K* are substituted which like the first set, are limited to certain sizes of tube. Within the lower miter gear *D* is a pocket which contains a spring which works against a collar placed on the countersink *L*; this spring always keeps the countersink casting *G* in its uppermost position when not in use. The countersink is a sliding fit in the miter gear and receives its rotary motion from a key *M* inserted in the side of the hub of the gear, a slot in the side of the countersink making it possible for the latter to slide up and down.

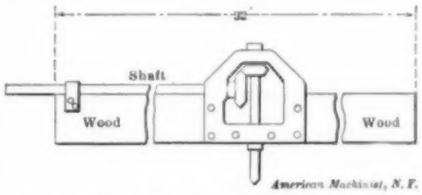


FIG. 3. ANOTHER COUNTERSINKING DEVICE

While the centering frame travels along and around the suction tube *N*, the shafts *B* and *C* which support it remain in a fixed location, finding bearings for their ends in two end frames *O* placed on the ends of the suction tube; these shafts and the casting *P* prevent the end frames from coming off the ends of the tube.

In the operation of the device shown in Fig. 3 two men handle it against one man for the one shown in Figs. 1 and 2. This is one of the disadvantages of the device shown in Fig. 3: to reach the different holes in the tubes it must be shoved along by hand and located as well as possible by peeping in the tube from the ends. The operators are liable to miss a hole in the center and it may not be discovered until after the work is shipped. When this device is countersinking the holes near the edge of the tube the end of the device will protrude from the end of the pipe a distance equal nearly to the whole length, which is about 10 feet; thus it requires plenty of space, and besides, the men operating it are apt to countersink the holes at various angles as the work is done by their pressure against the device.

The device shown in Figs. 1 and 2 overcomes the disadvantages mentioned and reduces the cost and time of machining the holes inside the tube. The work on the outside is done with ordinary machinery. These holes vary in number from 30,000 to 100,000 in the various sizes of tubes and the device is made to accommodate the sizes by the use of different sizes of end plates *O*.

Particular attention is drawn to the method of feeding the countersink from hole to hole: In Fig. 1 can be seen the main supporting shaft *B*, and in a groove in this main shaft is a feed screw *Q*. This screw rests in bearings at the end of the

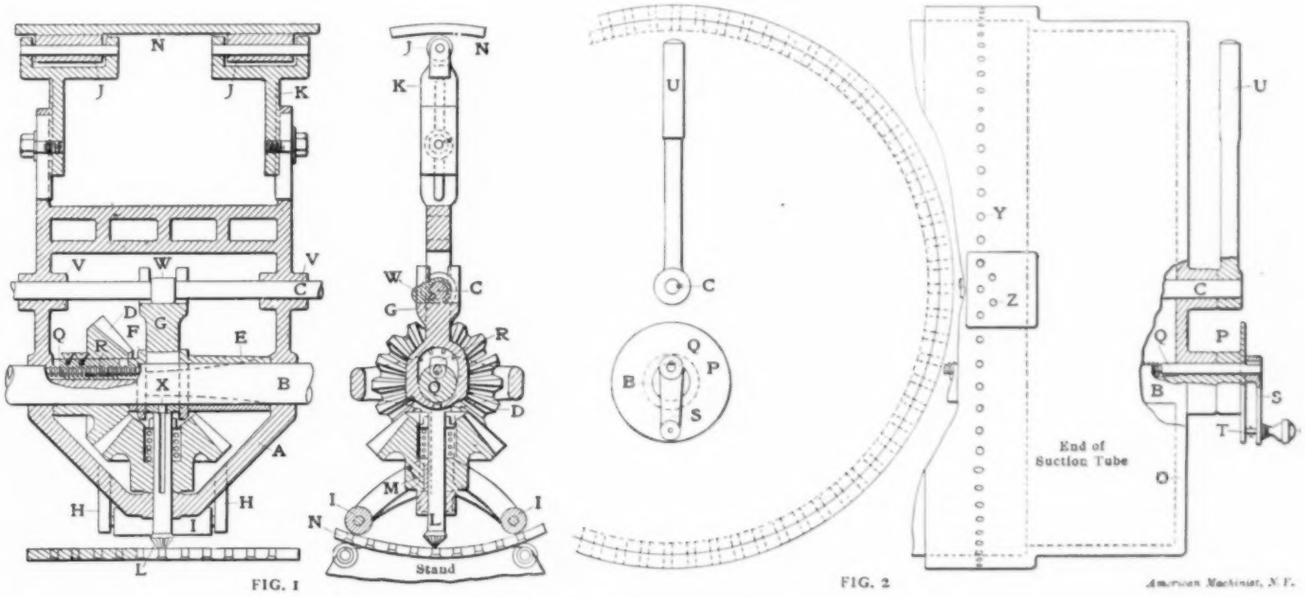


FIG. 1 FIG. 2

A PORTABLE COUNTERSINKING DEVICE

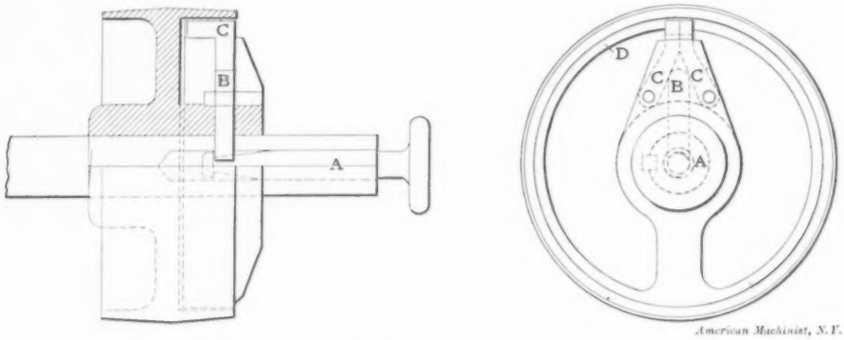
main shaft and surrounding the screw is the brass nut *R* which is fastened within the bore of the top miter gear *D* by means of two screws. The brass nut not only serves as a means for moving the gear along the shaft *B*, but also acts as a key for driving the gear when shaft *B* is rotated. At the extreme end of shaft *B*, outside of the end frames *O*, Fig. 2, is a small crank *S* keyed to the end of the feed screw *Q*. Upon turning this crank the screw forces the nut, gear *D* and all connected with it along the main shaft *B*. To regulate the amount of travel of the countersink so it will rest in correct position over each succeeding hole the index plate *D* is placed on the end of the main shaft *B* and several holes placed in it in line with the pin point *T*. When countersinking holes in the tube shown in the drawing six turns of the index crank *S* shown in Fig. 1, can be readily revolved to bring the line of holes being countersunk in a vertical position. A small pin placed in one of the small holes *Y* at each end of the suction tube locates it in the correct position with the holes in the tube; these pins pass through the plates *Z*.

Camden, N. J. GEORGE M. MILLER.

A Friction Pulley

The cut shows a small friction pulley. The object of this arrangement was to do away with all cumbersome brackets, arms and levers which go to make up the average pulley.

As can be seen by the cut, the tapered pin *A* is pushed in, which lifts the pin *B*,



A FRICTION PULLEY

which, in turn, opens the two dogs *C* and *C'*, spreading the friction *D*. It can be seen that the clutch is self-compensating for wear, as when any of the parts wear the center pin merely pushes in a little farther.

Jersey City, N. J. OSCAR JOHNSON.

Enlargement of a Cast Iron Piston

Not long since we received for repair, a 7¼x8¼-inch vertical gasolene engine of our own make, in which the piston had stuck and broken the connecting rod and one flywheel. Upon dismantling the engine, we had to remove the piston with heavy pries, and were unable to again introduce the top end of the piston into the cylinder, without driving.

The engine had been in successful operation for four years, and the cylinder and piston were worn to a mirror-like surface. The piston or cylinder was not scored in the least, nor jammed, nor distorted in any way. By using micrometers, we found the top of the piston to be less than one-fourth thousandth smaller than the cylinder bore, while the lower and middle portion of the same was 0.007 smaller than the cylinder bore.

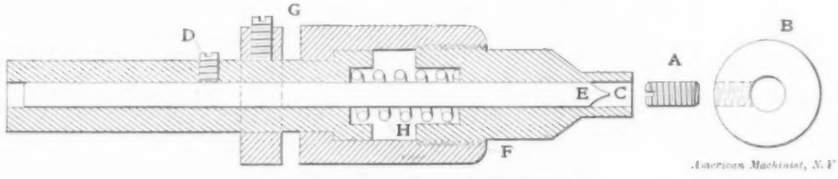
We got busy theorizing on why the top of the piston had become enlarged, as it most surely had done. We have recently seen much in technical papers, regarding the permanent enlargement of cast-iron fittings in high-pressure superheated steam service, and we concluded that the high temperatures of the cylinder contents had produced a similar effect on the piston. We turned 0.010 of an inch in diameter from the piston end and put the same back into service, and it gives no further trouble.

Iowa City, Iowa. FRED R. OGBORN.

A Semi-Automatic Screw-driver

The sketch shows a device for assembling small headless set screws in collars, etc. While the device is simple in construction it is a great time saver, and will insure all set screws being entered into the work to exactly the same depth. This fixture can be chucked in an ordinary bench lathe, which should be run at its lowest rate of speed.

In the sketch *A* is the set screw which is to be run into the collar *B*. First place



A SEMI-AUTOMATIC SCREW-DRIVER

the screw *A* in the recess *C*, the depth of which can be regulated by means of the screw *D* which holds the screwdriver blade *E* in place. Then take the collar *B* and press against the end of the screw *A*, which will cause the magnetized screwdriver blade to come in contact with the slot in the set screw and at the same time the collar *B* will force the sleeve *F* to slide back until it comes in contact with the stop collar *G* and the screw is then in place. As soon as the finished collar is removed the spring *H* forces the sleeve back into its original place ready to receive the next screw.

With this fixture the operator can work both hands at once; that is, with his left hand he can hold the set screws and as fast as one collar is assembled place another screw in the recess, while with his right hand he can hold the collars which are to receive the screws. The depth that the screw is to be run into the work can be regulated by means of the collar *G*.

Springfield. SUBSCRIBER.

are necessary to traverse the countersink from one hole to the succeeding hole in the same line.

Another interesting feature is the means provided for forcing the countersink down in the holes. This is accomplished by means of the lever *U*, which is keyed to shaft *C*. This shaft, like the main one, finds a bearing at each end of the suction tube. On the shaft *C* between the bearings *V* is the cam *W* which, though a sliding fit, is held in correct relative position to the lever *U* by a key which fits a keyway running the full length of the shaft. This cam is forced along the shaft *C* by means of casting *G* which is slid along by the bushings *E* and F, Fig. 1. While these bushings locate the casting *G* one way, the tit *X* and the shaft *C* locate it the other way. Upon turning the shaft *C* by means of lever *U* the cam *W* forces casting *G* down, an oblong slot being provided in the casting to make this movement possible. The end of the casting *G* coming against the upper end of the countersink *L* forces it down against the pressure of the coiled spring until the countersink is fed against the edge of the hole to be finished.

The motive power for driving the shaft *B* and the countersink is an electric portable drill which grips the end of the shaft outside of the end frames *O*.

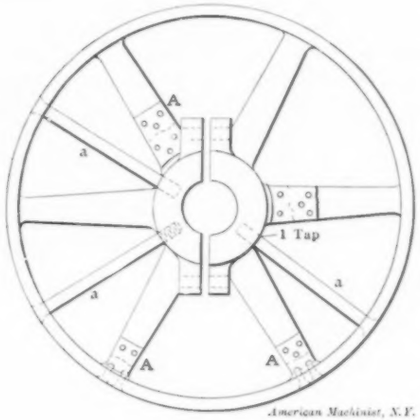
The suction tubes resting on rollers, as

A Pulley Patch Job

The accompanying sketch will illustrate in a fair manner, the method I recently employed in repairing the broken arms of a flywheel.

The wheeel was 5 feet in diameter, 12 inches face with four of the arms cracked as indicated by dotted lines under the strap patches at *A A A*, but the feature of the job is the three draw rods, *a a a* which were inserted as shown, in order to draw the crack together before riveting on the strap patches; in fact, the draw rods were of more importance toward strengthening the wheel than the patches.

Our instructions from the owner were



THE FLYWHEEL REPAIR

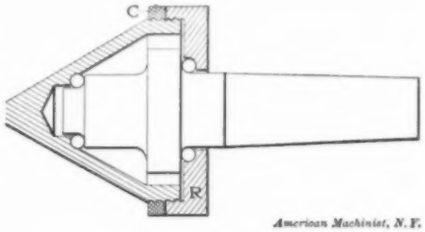
merely to put on the patches after the pattern of an old one which was already on, but the rigid safety-appliance laws in that State, led us to doubt whether or not the job would escape the discerning eyes of the inspector, so at the suggestion of one of my workmen, the draw bolts were put in which, at least, gave the wheel the appearance of being rigid and safe.

The owner was highly elated, as were we all, and the job was turned out to the credit of everyone concerned.

Trinidad, Colo. STANLEY EDWARDS.

A Ball Bearing Pipe Center

Owing to the difficulty experienced in turning, and especially screwcutting large pipes in the lathe, the following center was devised and found to allow of a greater nicety of adjustment than any I have seen. It consists of elongating the conical part of the center and threading it, preferably with a fairly fine thread. A ball race *R* is then screwed onto this and incidentally the balls at the same time, until the required nicety of adjustment is arrived at. The ball race is then locked in this position by means of the threaded collar *C*. The cone, ball race and collar, of course, revolve together and on large sizes the center is easily ground true in place by using the ball race and collar as a small pulley and running a narrow belt on them, while the cone is ground true by



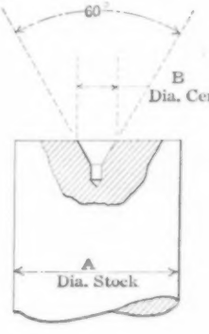
A BALL BEARING PIPE CENTER

means of a hand-grinding attachment. Although the initial cost of making this type of center may be a little more than some others, it will outlast two or three of the other types and at the same time keep true much longer.

Guildford, England. W. J. PARSONS.

Uniform Centering

The lack of uniformity in centering bar stock which is to be machined, has been brought very forcibly to my notice in the past. On looking over some work I found



A	B	Use Conb. C'Sink
$\frac{1}{4}$" to $\frac{7}{16}$" Inc.	.08"	.125" Dia.
$\frac{1}{2}$" to $\frac{11}{16}$" Inc.	.15"	.20" Dia.
$\frac{3}{4}$" to $\frac{15}{16}$" Inc.	.18"	.20" Dia.
1" to $1\frac{7}{16}$" Inc.	.20"	.20" Dia.
$1\frac{1}{2}$" to $2\frac{3}{16}$" Inc.	.22"	.30" Dia.
$2\frac{1}{4}$" to 3" Inc.	.25"	.30" Dia.

American Machinist, N.Y.

TABLE OF SIZES OF COUNTERSINKS IN SHAFTS

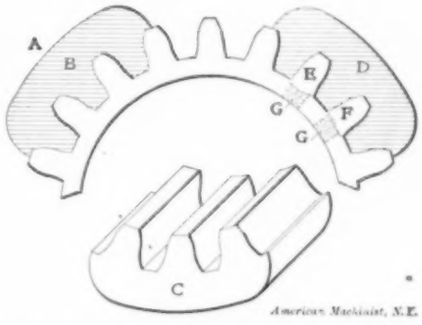
a great difference in the diameter of the center holes; some too large and many too small in proportion to the diameter of the stock and I decided to see if I could not remedy this fault so I consulted others and we agreed upon approximately the right depth.

I had the inclosed table made and blueprints pasted on a piece of board which was fastened to the shipper lever of the centering machine and in a short time we noticed a vast improvement in the uniformity and also better results in the work.

West Lynn, Mass. ROBERT L. PERRY.

Making a Pattern of a Broken Gear

In a small repair shop, we frequently have gear wheels brought in with one or more cogs broken, and in most cases, the shape of the remaining cogs are practically as good as new.



MAKING A PATTERN OF A BROKEN GEAR

To avoid the time and expense necessary to make a pattern, we devised a quick, easy method of "crowning" the broken teeth, enabling us to use the old gear for the pattern and get smooth, even-shaped teeth in the casting.

This method may be readily explained by referring to the accompanying line cut, showing a section of a spur gear having two adjoining teeth broken.

Take a strip of tin as wide as the face of the gear and long enough to bend in a shape similar to that at *A*, spanning four teeth, or two more than the number broken. Lay the gear on some level surface, back up the tin with sand and run the space *B* with babbitt. This gives us the impression, or die *C* for forming the crowns.

In the rim, drill and tap two holes *G* at the base of each broken tooth, the size of the holes depending on the size of the tooth. It is unnecessary to smooth off the fractured edges any more than to get the drill started. After this coat the die with graphite, or oil, to prevent the crowns from adhering to it, and place it over the gap as at *D*. Then clamp the die to the rim and run the teeth *E* and *F* with babbitt, or lead. Remove the die and the pattern is ready for the molder.

We have used this method on both spur and bevel gears, with such good results and saving of time that I think it good enough to pass along.

CLAUDE H. SANFORD.

Fayetteville, Ark.

A Heavy Duty Box Tool

Not long ago I accepted a position with a firm which does a large amount of machine-screw work and was immediately impressed by some box tools which were eating up the stock in a manner most gratifying. These tools were being used in Cleveland automatics and some screw machines of special construction similar in many respects to the Cleveland and were utilized to turn a wide range of screw and pin bodies. The roughing and finishing was done by one box tool with but one cutter and rest and the surface finish on the body of the pieces made was for smoothness and polish all that one could desire.

This tool with but few minor alterations can be used in the various makes of automatic screw machines; but I am informed (and it seems a singular fact) that it is not used in more than four shops throughout the country.

Referring to the detail sketches, Fig. 1 shows two views of the head or business end of the tool which joins the body, Fig. 2, at the points *O*, where it is held firmly by a 5/16 square-head cap screw which passes through the slot *S*, Fig. 2, in tongue *t* and engages the tapped hole in the head indicated at *F*, Fig. 1. The tongue *t* enters a corresponding groove *x* in the back of the head, Fig. 1, and being a close fit overcomes any tendency on the part of the head to twist and also supports the head while the tool is operating. The 5/16 square hole *H*, Fig. 1, is for the cutter and has a forward slant of 5 degrees, but the cutter is always tangent with the periphery of the stock; adjustment for the desired turning size being made by releasing the clamping screw and sliding the head along the tongue *t* on the face of the body. The cutter is firmly held in position by a 5/16 set screw which enters tapped hole *A*, Fig. 1. Tapped holes *B*, *C* and *D* are for three rest adjusting screws and hole *C* is for a dog-point set screw which clamps the rest in position after adjustment. *R* is a milled recess in the face of the head to accommodate the rest of which two views are shown in Fig. 3. The top, right side and bottom of the rest are beveled forward to insure the piece seating itself firmly against the bottom of *R* when the adjustment for bearing is made. The notch *n* in the rest will always vary according to the diameter of piece turned and as the recess *R* permits of but slight adjustment of the rest up or down it is necessary to have several rests with notches ranging in sizes by sixteenths from ¼ inch, the smallest practical size, up to ⅞ inch. The bearing faces of the rest should be relieved gradually by a backward bevel of at least 0.002 inch which can readily be determined by using a reliable square, and the bearing faces should both be ground alike and perfectly smooth.

A set screw fitting hole *G*, Fig. 2, is used to hold any tool entered in the chamber of the shank for the purpose of chamfering, facing, centering or drilling the end of the work.

The method of adjusting the tool to turn a piece, say ⅝ inch diameter, should be as follows: Place the tool in the turret in its given position and bring in line with the chuck into which the proper size stock has been entered. Slide the head, Fig. 1, along the tongue *t*, Fig. 2, until the cutter is as nearly as can be judged 5/16 inch off dead center; clamp lightly and try by hand. Measure the turned part to determine the variation over or under the size desired and repeat as often as necessary until the turned part measures from 0.002 to 0.006 inch over the required dimension.

It has been found essential for superior work requiring a polished finish that the turned part of the work be left slightly over size, but the amount of surplus stock will necessarily vary according to the speed of spindle and feed of tool. If the speed is fast and the feed fine, less will be required than when the conditions are reversed. As these conditions vary so there is no hard and fast rule to go by so that the matter is up to the judgment of the operator who, with a little practice, will soon become expert. When the proper size is obtained, place a properly prepared rest in the recess *R* in the head and run the tool back over the turned part of the bar; turn down the screw in hole *B* with the fingers until the rest is pressed against the work, then relieve very slightly. Do the same with the screw in *D* and then with the one in *C*; turn home securely the screw in *E* and withdraw the tool from the work.

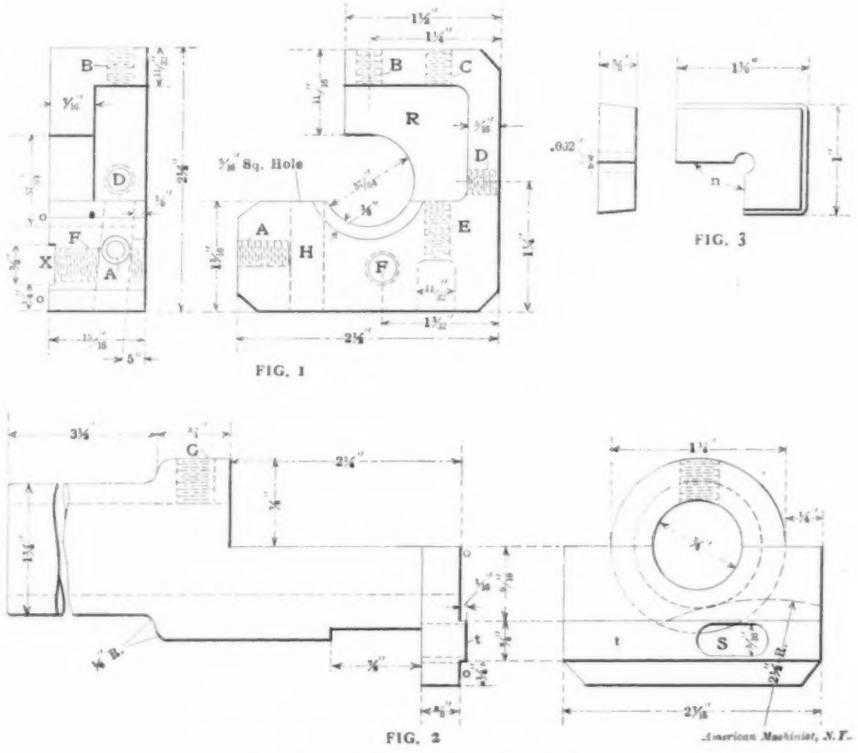
There are usually perceptible on the turned surface of the work two parallel lines which indicate the points of contact between the work and the rest and which by comparison enable one to readily perceive any inequality in the relative pressure of the two faces of the rest upon the work. As there should be an equal bearing upon both faces of the rest it will frequently be found necessary to advance or withdraw one or the other of the adjusting screws in *B* and *D* and repeatedly run the tool over the turned part until the points of contact are all but imperceptible upon the surface of the turned part before the tool can be safely tried with the machine feed.

If the work appears "chewed" it signifies that the rest is hugging the work too closely; if nothing appears on the surface but the cutter rings the rest is too far away. A little turn on the screw in *D* will usually remedy the latter trouble but it is generally necessary to readjust the rest to correct the former fault.

The foregoing is an adaptation of the method usually followed by an operator, E. Hovey, who has been eminently successful in the use of this tool, and it is commendable as a course of procedure for those lacking experience.

When the tool is correctly adjusted it will hold up nicely under a very heavy cut and a good clean job is the result.

Detroit, Mich. B. Bubb.



DETAILS OF HEAVY-DUTY BOX TOOL

Arbor for Turning and Facing Piston Rings

The body *A* is made of machine steel and the shank turned to fit the spindle of the lathe and turned. The angle at *D* is about 15 degrees. It is threaded at *F* to receive gray-iron ring nut *C*.

B is made of gray iron bored a nice fit for the taper *D*, and split at *E*. The outside diameter of *B* fits the bore of the piston rings. To operate, place the piston ring on *B* and tighten *C*, which expands *B* and holds the piston ring firmly.

Fig. 2 shows a combined turning and facing tool, which consists of a body *A* made of machinery steel into which was inserted two pieces of ¼-inch square high-speed steel *B* and *C*. The tool *B* was ground square on end with both corners ground to make a nice smooth cut. *C* was ground on an angle, as shown with inside corner to do cutting. The tools *B* and *C* were inserted in holder *A* and adjusted until the space *D* was a trifle wider than the size of the piston ring. The screw *E* is then adjusted until the size is right.

The tool is used in the ordinary tool post of the lathe. Turn the outside diameter of the piston ring with the high point of the tool *B*, Fig. 2, and when the ring is turned to size, set the dial on the cross-feed screw at zero and proceed to face both sides of the ring at once.

The advantage of this style of arbor and tool is that the outside and sides of the ring are finished with one setting and consequently must be true.

Buffalo, N. Y. E. A. S.

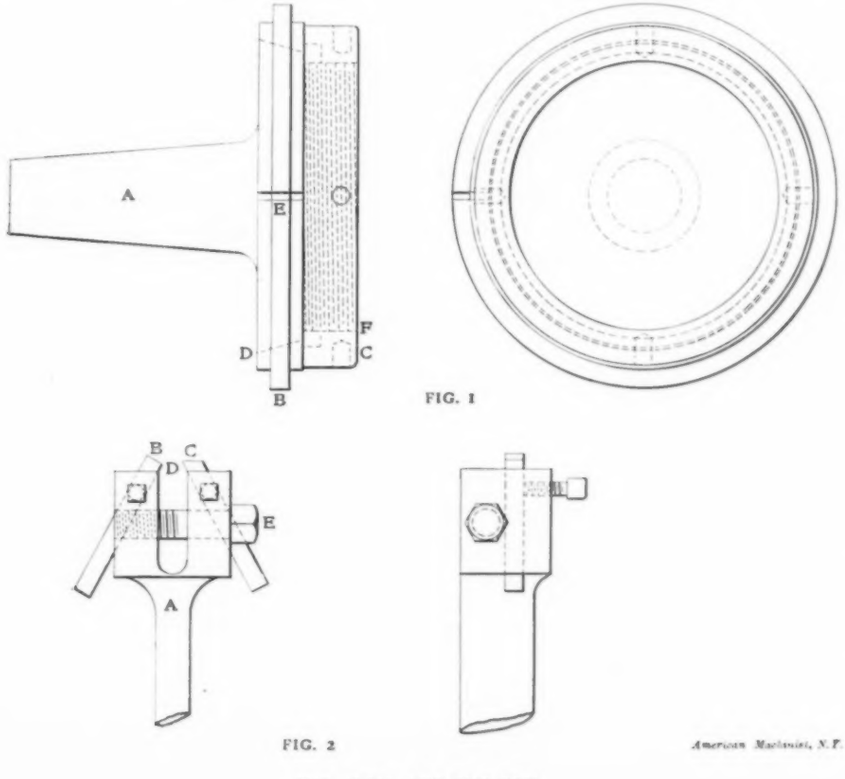


FIG. 1

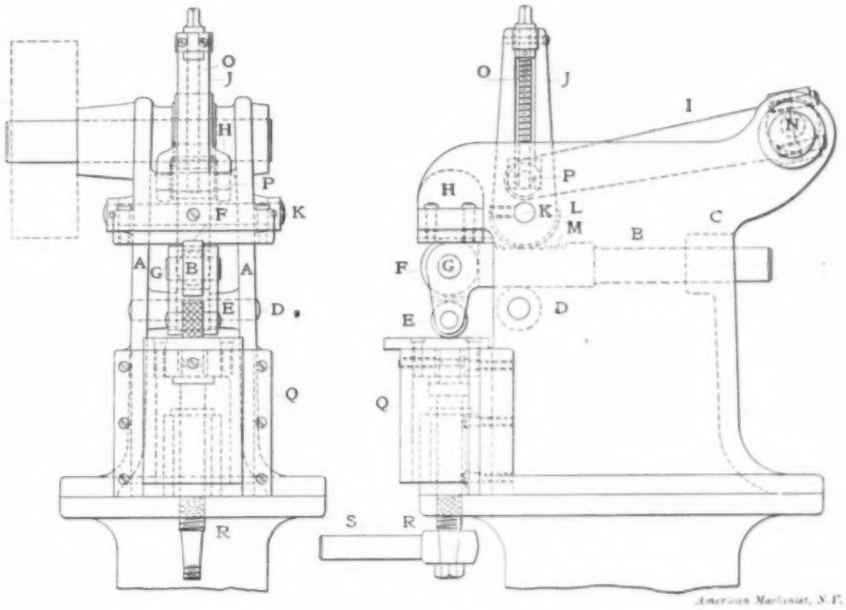
FIG. 2

THE ARBOR AND THE TOOL

Nurling Machine for Flat Work

Nurling such as is done with the ordinary tool on the periphery of screws, etc., is well understood in most manufacturing plants, but when flat nurling is required as on the small flat parts of typewriter levers, for example, special machines are used, one of which is shown in the accompanying sketch.

The construction of this machine is simple and ingenious. It consists of a cast-iron head *A* which is mounted on a pedestal. Working through the center of this head is a ram *B*; the rear end of this ram is round and slides in a long bearing *C*, while the forward end, which is square, rides on a roller *D*, which works on a stud set in the head *A*. To prevent the ram from lifting as the nurl *E* comes against the work, a second roll *F* is placed



NURLING MACHINE FOR FLAT WORK

on a stud *G* in the forward end and runs in a groove and against the lower face of an overhanging arm *H*. By means of this the ram is held within three points, two of which are the rolls *D F*.

The drive of the ram is by an arm *I*, which has one end attached to the rocker *J* above the pivotal point *K*. The lower end of rocker arm *J* is provided with gear teeth *L* which mesh with the rack *M* on the face of the square section of the ram *B* and drive the ram back and forth. The movement in this machine is accomplished by eccentric *N*, which gives the ram a maximum movement of ½ inch, which is sufficient for typewriter work. It will readily be seen that by changing a few dimensions and the eccentric pin a longer travel of the ram can be had. The rocker arm *J* is provided with a long adjusting screw *O* for the block and stud *P* that connects with the end of rod *I*.

At the front of the machine is a table *Q* which is adjustable up or down by means of a screw *R* to which is attached the lever *S*.

In operation the work to be nurled is set in a holder on the top of the table and forced up against the nurl carried in the end of the traveling ram.

Plainfield, N. J. A. A. FULLER.

Discussion of the Previous Question

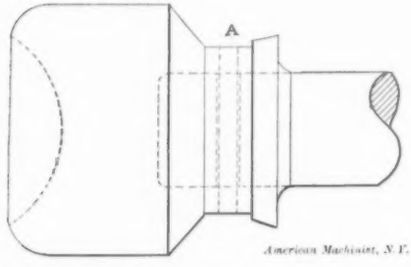
Letters from Our Readers Showing How Many Men of Many Minds Look upon Various Subjects Opened up in Previous Numbers

WE PAY FOR THESE ALSO

Pneumatic Snaps

From the inquiry on page 753, Vol. 31, Part 2, *re* snaps, your correspondent seems to have struck the same difficulty that all users of large pneumatic snaps meet, and in a later number, another correspondent suggests a method of hardening, probably thinking the fault is there, but the stems will break when not hardened at all.

On page 194 of the current volume Mr. Holt sends his method of forging and hardening the snaps, quoting ⅞ inch as his largest rivet. The worst trouble is met when one uses 1¼ inch and upward. With our broken snaps we had adopted the method shown in the cut (typical of large snaps); that is, the broken snap after annealing is bored out and a false stem shrunk in, but this, while being cheaper than making a new snap, is far from satisfactory, the stems breaking as before at the line drawn to represent the fillet (although quite soft). The snaps break when the rivet head is nearly home



A PNEUMATIC SNAP

and the riveter is rolling his hammer round. In doing this he gets onto the cold metal with the edge of the snap.

In discussing this matter with a fellow toolmaker, who, though not a snap user, makes a number of large snaps for a neighboring bridge builder he told me that they had had the same trouble, and after adopting practically the same method that we were using, they tried as a further experiment putting the stems in quite loose and keeping them in with a pin, as shown at *A*, lightly riveted over. The snap and stem are drilled through with a 3/16-inch drill, the stem is then taken out and a ¼-inch drill is run through the same hole. Thus when the rivet is in there is a slight lateral movement of the stem which is free also lengthwise within the limit of the hole and pin. The stem should be quite slack in the snap, and acts merely as an extension of the hammer, the real blow being transferred to a point much nearer the rivet without any apparent loss of efficiency. Since adopting this method he assured me that they are doing at least three times more rivets per snap than with the shrunk method. These stems fail across the hole, either by crushing, or breaking, but if when they appear tight they are taken out and the drill again run through, the stem will often do more rivets than before. A strong point in favor of this method is the ease with which the stems can be replaced.

Woolwich. WALTER G. GROOCOCK.

Pulley Crowning on Engine Lathes

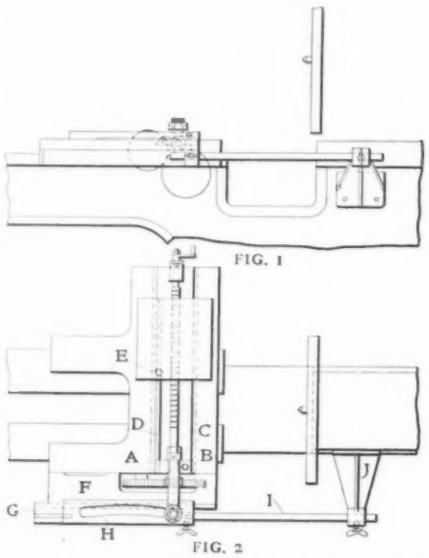
I read with interest the article on page 393 by E. W. H. on the above subject, also the editorial comment which I fully indorse. I think also a flat portion would be found near the center of the pulley. No allowance is made for the dead center of the crank lever and the consequent slower movement of the screw in relation to the carriage movement.

Having been "up against" this problem on two occasions, I inclose sketches of my second attempt to adapt an English made engine lathe to crown pulleys. It may be a little more costly than the idea of E. W. H., but as most things in this line are worth doing well if done at all, I make no apology for the cost.

Figs. 1, 2 and 3 are three views showing the attachment complete, Fig. 4 showing the lathe carriage as supplied by the makers. The original back bearing of the cross-feed screw I machined off, and fitted the bearing *A* a sliding fit in the V. When not in use for crowning pulleys it is clamped in position by the screw *B*. The collar *C* was then fixed on the screw, as shown, and a portion of the thread on the front end was turned off to allow end movement.

The rod *D* was fixed to the bearing *A*, and is free to slide through the hole bored through the tool post. This rod when clamped by the screw *E* prevents any irregularity of movement between the tool post and the sliding bearing *A*.

F is a cast-iron box bracket fixed to the back of the tool carriage with studs. *G* is a cast-iron slide to which the former plate *H* is fixed, the slide and plate being held stationary by the rod *I* and bracket *J*. To operate, the cutting tool is first brought to the center of the pulley to be turned. The former plate is then brought central with the pin and roller *K* and bolted to the slide *G*. The screw *B* is then removed.



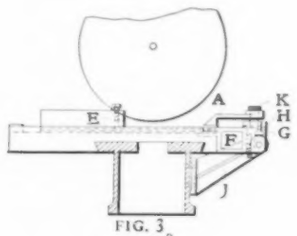


FIG. 3

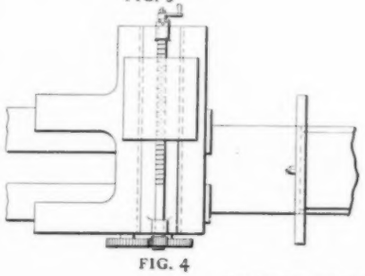


FIG. 4

American Machinist, N.Y.

FIG. 2

PULLEY-CROWNING ATTACHMENT FOR THE ENGINE LATHE

The carriage can now be brought back and the cut put on, the rod *D* being clamped tight by the screw *E*. This screw must be released when putting on subsequent cuts or when facing the edges of the rim or hub. This attachment does not interfere in any way with the power cross-feed and it is a simple matter to detach when not required.

The alteration was made especially to deal with one class of pulleys of which we turn a large number, but not sufficient to

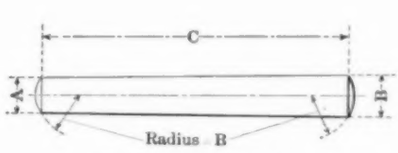
warrant the outlay for a special lathe. Any desired camber or taper within certain limits can be obtained by changing the former plate *H*.

I make no claim of originality for this attachment; it is merely an adaptation of the well known taper attachment.

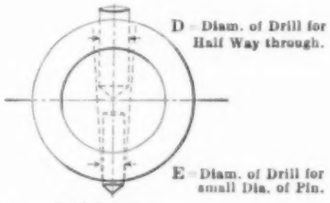
Belfast, Ireland. F. P. STRACHAN.

Drill Sizes for Taper Pins

The table by T. C. Schaefer at page 388 relating to taper pins reminds me of one I put into use some time ago on similar lines, of which a copy is given herewith, an important difference, however, being the provision made for enlarging the holes for the longer pins half way through, to minimize the work on the taper reamer.



Taper 1 in 48 = ¼" per Foot



Drill Diagram.
Nos. of Drills are Morse Twist.
Drill Co's and allow for Reaming

Stock No.	A	B	C	D	E	No. of Reamer	Sizes in Stock	Morse Let. No. of Pin
1 A								
1 B	.067"	.077"	13/32"		51	.04		None
1 C	1/16"	.077"	21/32"		1/16	.04	●	"
1 D								
1 E	.083"	.094"	13/32"		45	.03		"
1 F	5/64"	.094"	25/32"		47	.03	●	"
1 G								
1 H	.099"	.112"	29/32"		39	.02		"
1 J	3/32"	.112"	29/32"		42	.02	●	"
1 K								
1 L	.114"	.128"	33/32"	32	32	.01	●	"
1 M	7/64"	.128"	29/32"	32	36	.01		"
1 N								
1 P	.140"	.156"	¾"	24	28	0		0.¾"
1 Q	.135"	.156"	1"	24	29	0	●	0.1"
1 R								
1 S	.151"	.172"	1"	20	24	1		1.1"
1 T	.146"	.172"	1¼"	21	27	1	●	1.1¼"
1 U								
1 V	.172"	.193"	1"	14	17	2		2.1"
1 W	.167"	.193"	1¼"	15	18	2	●	2.1¼"
1 X								
1 Y	.193"	.219"	1¼"	5	10	3		3.1¼"
1 Z	.188"	.219"	1½"	7	12	3	●	3.1½"
1 AA	.183"	.219"	1¾"	7	13	3		3.1¾"
1 AB								
1 AC	.219"	.250"	1½"	A	2	4	●	4.1½"
1 AD	.214"	"	1¾"	1	3	4	●	4.1¾"
1 AE	.209"	"	2"	1	4	4	●	4.2"
1 AF								
1 AG	.253"	.289"	1¾"	I	F	5	●	5.1¾"
1 AH	.248"	"	2"	H	E	5		5.2"
1 AJ	.243"	"	2¼"	H	D	5	●	5.2¼"
1 AK								
1 AL	.295"	.341"	2¼"	O	M	6	●	6.2¼"
1 AM	.290"	"	2½"	O	L	6	●	6.2½"
1 AN	.285"	"	2¾"	5/16"	L	6	●	6.2¾"
1 AP								
1 AQ	.352"	.409"	2¾"	V	S	7	●	7.2¾"
1 AR	.342"	"	3¼"	3/8"	11/32"	7	●	7.3¼"
1 AS	.332"	"	3¾"	U	Q	7	●	7.3¾"
1 AT								
1 AU	.418"	.492"	3½"	29/64"	Z	8		8.3½"
1 AV	.408"	"	¾"	29/64"	15/32"	8		8.4"
1 AW	.398"	"	4½"	7/16"	X	8	●	8.4½"
1 AX								
1 AY								
1 AZ								"

American Machinist, N.Y.

TABLE OF DRILL SIZES FOR TAPER PINS

The table was arranged to take a number of sizes, but only those marked by a dot in column *G* were intended to be stocked at first. If others were added then it was the intention to denote these also by a dot as required, without disturbing the rest of the table.

Glasgow, Scotland. H. A. DUDGEON.

Finding the Area of a Flanged Spherical Segment Drawn from Sheet Stock

Mr. Zeh, in reply to an inquiry under the above heading, at page 527, states that taking *E*, Fig. 2, as the radius of the blank used for obtaining the flanged spherical segment, whose cross-section is shown in Fig. 1, we obtain a practically accurate result. If he had combined his formulas he would have found that it gives an accurate result; that is, if we do not consider the expansion or contraction of the metal. The formulas he used in obtaining the area are as follows:

$$Area\ of\ Segment = \frac{\pi}{4}(A^2 + 4B^2).$$

$$Area\ of\ Ring = \frac{\pi}{4}(C^2 - A^2).$$

Adding we obtain

$$Area\ of\ Work = \frac{\pi}{4}(C^2 + 4B^2).$$

From this we can easily see that the radius of the blank is

$$\sqrt{\frac{C^2 + 4B^2}{4}} \text{ or } \sqrt{\left(\frac{C}{2}\right)^2 + B^2}.$$

But since *E* is the hypotenuse of a right triangle, of which *B* and $\frac{C}{2}$ are the two sides,

$$E = \sqrt{\left(\frac{C}{2}\right)^2 + B^2}.$$

Therefore the radius of the blank is *E*.

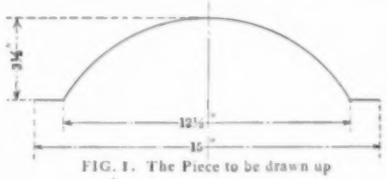


FIG. 1. The Piece to be drawn up

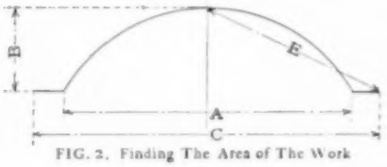


FIG. 2. Finding The Area of The Work

FIG. 3. A=O, B=O

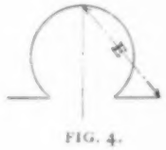


FIG. 4.

FIG. 5.

FIG. 6. A=C

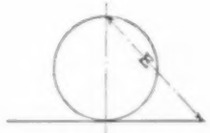


FIG. 7. A=O,

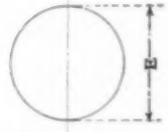


FIG. 8. A=C=O

American Machinist, N.Y.

FINDING THE AREA OF SHEET-METAL WORK

Figs. 3 to 8 show the cross-sections of several different surfaces of revolution whose area is equal to a disk of radius *E*. Of course, these are not all useful to the diemaker, but are interesting as a result of the problem.

In the problems given,

$$E = \sqrt{(3.5)^2 + (7.5)^2} = 8.278$$

and the area equals

$$\pi E^2 = \pi \left\{(3.5)^2 \times (7.5)^2\right\} = 215.199.$$

Schenectady, N. Y. W. L. TRYON.

Machine Supports

The article by Entropy on page 621 is interesting, but I think he has slipped a cog if he fails to understand why the left-hand member of the lathe in question is shorter than the right-hand end. It looks to me as if the large cone pulley has considerable overhang as it is, and if the left end was made longer, the overhang would be still greater.

ALONZO G. COLLINS.

Philadelphia, Penn.

I take exception to a paragraph in Entropy's article under the above heading at page 621 where he says, "When Nature goes beyond one leg to two, it is only to support the most insecurely supported of all beings, man." How about the banyan and mangrove trees which are found in the tropics? These trees spread over vast areas and have hundreds of supports in the shape of extra trunks which drop from the branches and take firm root as further support becomes necessary. The tree, of course, begins with a single stem, then as necessity arises another stem is added and then a third, so that the three-legged dog referred to by Entropy in his article is not the only three-legged thing that occurs in Nature. Thus the tree grows on adding trunk after trunk until there are hundreds of them, Nature doing for the tree as the lathe builder does for the lathe, adding a stem or a leg as it becomes necessary.

New York. E. A. DIXIE.

Distributing Trade Catalogs

"Entropy's" article on page 615 was very interesting. I distribute machine-tool catalogs over a large territory, and would like to get the views of other men who use catalogs and buy machinery, so that I may hand them out in a way they will like. That's what I am here for!

Birmingham, Ala. CLERICUS.

Filing the American Machinist

Some weeks ago I read an article by an English subscriber telling how he bound and filed his copies of the AMERICAN MACHINIST and asking how others managed. In knocking about I have seen numerous methods employed for preserving *Power* and the AMERICAN MACHINIST.

Our master mechanic cut out the articles he wanted, folded once, numbered them, placed them in separate envelops, also numbered, and kept them in a letter-file box. He indexed all articles in a card-index system. He said it took only a few minutes a week to keep it up and it was very valuable.

Our chief engineer had bound volumes of *Power* since 1892, and stated they were the best library he had because they "kept uptodate." The first volume he bound himself, making a stiff cover of cardboard, neatly covered with black oilcloth with thin leather on the back and edges of the book. The next few volumes were bound with your "ready binder." Two volumes were bound by taking the advertising leaves off, laying the remainder neatly one above the other, then making a hole through them with a belt punch and fastening them with 4-inch paper fasteners. The last few volumes were bound by using a shoestring instead of paper fasteners. The yearly index made these volumes a veritable encyclopedia of information.

Our M. M. copied all formulas which pleased him into a loose leaf, leather-covered notebook, arranged alphabetically. He then cut the entire article out and pasted it in a scrap book.

Our engineer said he would not take $25 for a collection of clippings made by himself during 20 years' service. From the office he had obtained a pair of heavy covers, having two 3-inch steel posts or pegs to hold the sheets. He tore out the whole page on which was the article he wanted, punched holes in the margin, and inserted between the covers. He had no indexing system.

These are a few of the best methods I have seen employed to preserve articles. I have always found that the mechanic who bound his papers or kept clippings was progressive, uptodate, cheerful and optimistic. He always praises technical papers and tells of the benefit he has derived from them.

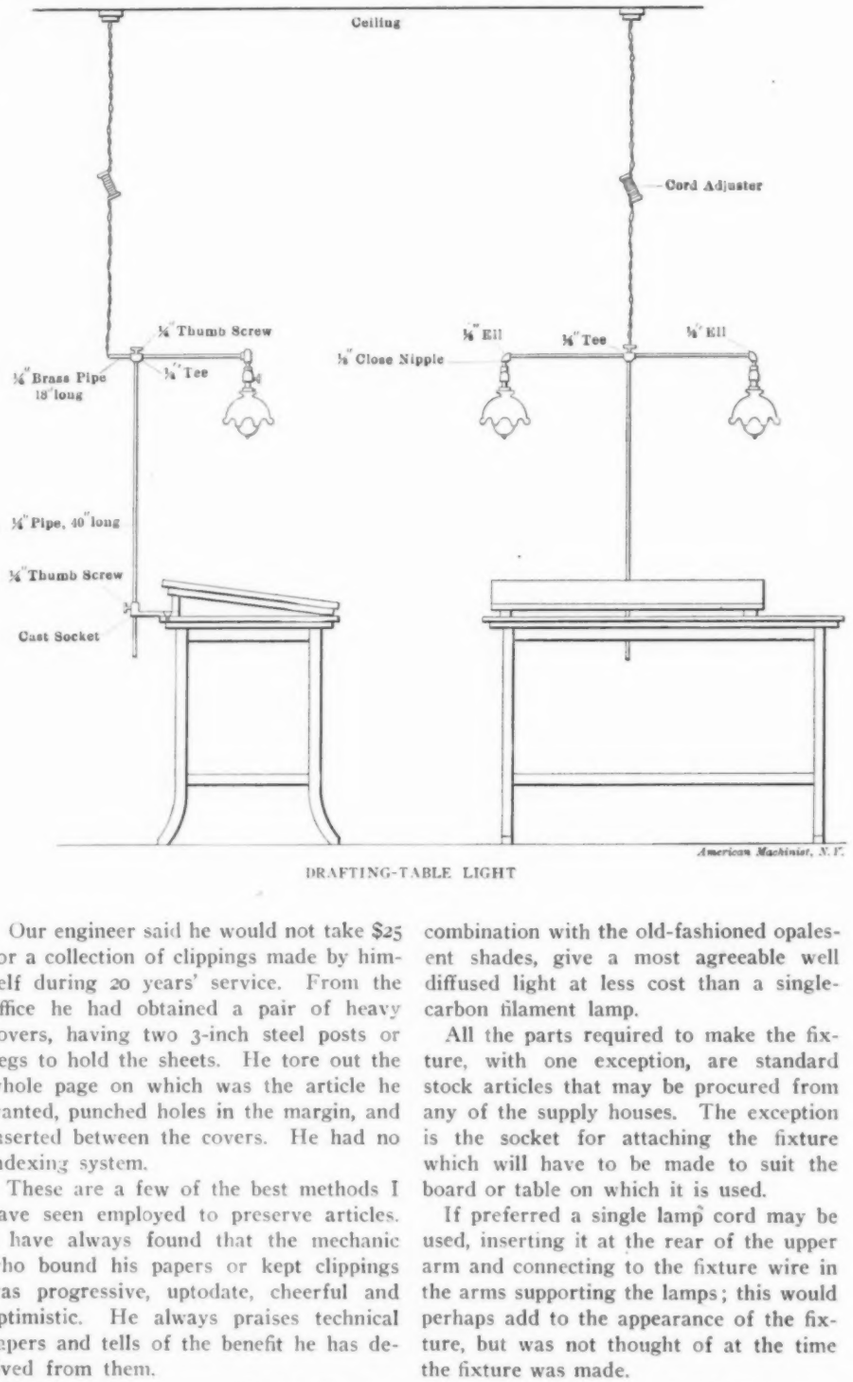
Portland, Me. RALPH BLISS.

Drafting Table Light

Referring to the drafting-table light illustrated and described on page 420, will say that we have recently moved into new shops; at the old place we had a fixture the equivalent of one described, but not quite so convenient. We are now using the fixture shown which we like very much better.

The advantages are that having two lights there are no shadows, and once properly located it is unnecessary to alter their position. Both vertical and horizontal adjustments are provided.

The lamps hang vertically, enabling the use of 25-watt tungsten lamps which, in combination with the old-fashioned opalescent shades, give a most agreeable well diffused light at less cost than a single-carbon filament lamp.



DRAFTING-TABLE LIGHT

All the parts required to make the fixture, with one exception, are standard stock articles that may be procured from any of the supply houses. The exception is the socket for attaching the fixture which will have to be made to suit the board or table on which it is used.

If preferred a single lamp cord may be used, inserting it at the rear of the upper arm and connecting to the fixture wire in the arms supporting the lamps; this would perhaps add to the appearance of the fixture, but was not thought of at the time the fixture was made.

Tecumseh, Mich. L. M. COLLINS.

National Association of Manufacturers

Reaffirmed Principles and Policies, Stated Belief in Immediate Business Activity and Was Addressed on Foreign Trade and Business Legislation

EDITORIAL CORRESPONDENCE

The first session of the fourteenth annual meeting of the National Association of Manufacturers, held on the afternoon of May 17 at the Waldorf-Astoria, New York, received the reports of three standing committees. The committee on Banking and Currency reported very briefly on our inadequate banking system, stating that it was invented at the time of the Civil War, and while useful at that period of our history, today is entirely lacking in qualities of flexibility. The system of the Bank of England was also reported against, while the system of the Bank of France was praised. The report ended by advising that the association endorse the Fowler Currency bill and recommend its passage by Congress.

A traffic or freight committee was appointed at the last annual meeting to resist the, then, threatened advance in freight rates. It found, however, that the proposed increases were not put into effect, and on asking for instructions it was directed by the Executive Committee to ignore isolated instances of increase as certain members of the association were in favor of the attempt on the part of railroads to advance their rates. Speaking generally in regard to the advance in rates, the committee's report stated: "There have been indications, however, that the railroads are advancing rates by indirect methods of *which they are master*, such as changing merchandise from a lower to a higher classification by increasing the rate on single articles or commodities, by changes in rules, by increasing the minimum carloads, by imposing switching charges where no charges had heretofore been made, or increasing such charges as were already made, and in various other ways." To show the extent of the rates that have been filed with the Interstate Commerce Commission, it is stated that between the dates of July 1, 1906, and January 15, 1909, 3,000,000 pages of schedules have been filed; estimating an average of 50 items per page gives a total of 150,000,000 rate items.

The committee advised that it be made permanent in the following words: ".....we recommend that the Traffic Committee be made permanent. That a special department be organized in the New York office of the association to deal with questions of this nature. We urge the appointment as head of this bureau of a competent man, thoroughly familiar with freight and express rates and conditions, who will be able to recommend the policy of the organization on general traffic matters, so that the National Association of Manufacturers can make its influence felt on the side of right and justice with the railroads and with the shippers."

In the section devoted to express rates the committee recommended that the questions of express rates should receive attention in the same way as the freight-rate problems.

Industrial Education

Anthony Ittner, chairman of the committee on Industrial Education, presented a 19-page report, which, after considerable uncertainty of opinion on the part of the members of the convention, was finally read entire by the secretary. In view of its length, the report is remarkable for two reasons: With the exception of the first two pages, or thereabouts, the entire report is more or less an unskilful compilation of quotations from various reports and bulletins issued during the last two or three years and devoted to the broad subject of industrial education. The text of the report, or at least of that part which was prepared along the path of least resistance, that is, by quotation, is found in this paragraph: "In order that it may be known to our membership what is being said in addresses and written reports by the leading educators and industrial bodies of the country, we will give extracts from those which we consider most pertinent and interesting." Needless to say, there is little of interest or profit in this re-hashing of previously presented ideas.

So far as the report was original it was extremely, and in our opinion, unduly optimistic—even to the extent of suggesting that the committee has little or nothing more to do! This optimism is shown in the final paragraphs of the report as follows:

"We are pleased to state, however, that industrial freedom is in sight. It will be a matter of but a few more years when we will be blest with the fullest possible industrial freedom, as was vouchsafed to us by the Declaration of Independence and the Constitution of the United States. At least we hope so.

"Wishing to set before you the situation as clearly as possible, we have quoted extensively from the reports of other organizations interested in industrial education, and we now conclude our somewhat lengthy report by the statement that there is every reason to be encouraged, since there is abundantly increasing evidence that industrial training, such as will graduate finished skilled workman, has a bright future."

Our Manufacturers' Greatest Foreign Opportunity

The address of the afternoon was given by John Barrett, director of the International Bureau of American Republics. He addressed the convention on South America; stating that it held for our manufacturers their greatest foreign opportunity. Today our exports are approaching the $2,000,000,000 mark; that is, $25 for every person in this country. Yet a close watch of the tariff speeches that have been and are now being made in Congress has failed to show a single legislator who has considered the effect of our tariff revision upon our export trade. Latin American government officials and editorial writers have not hesitated to say that the United States of America prepares its tariff schedules from purely selfish motives. It absolutely fails to consider the effect of such schedules upon other countries and upon export trade.

Industrially, South America today is in the same position that was occupied by the United States 70 years ago, except that in place of the small population which we then had it has a population of some 70,000,000 of people. It lacks skilled labor, capital and cheap fuel, but has enormous stores of natural resources. To our discredit it is drawing inspiration and capital from Europe rather than from us. Great Britain has invested in Argentine, alone, some $1,500,000,000 of capital; it is doubtful if there is $20,000,000 of American capital in that state.

In regard to purchasing manufactured articles Mr. Barrett said: "It is all poppycock to talk of any prejudice of Latin America against us. They will buy just as quickly from the United States as from Europe, but we must not levy taxes against them."

In closing he made a plea for ambassadors who would pay more attention to commercial and less to social duties; for a tariff commission which would furnish adequate information in regard to the cost of production and reasonable rates; for marine transportation between the United States and all parts of South America to facilitate the rapid handling of mail and passengers, and for widespread and adequate foreign banking facilities.

The secretary of the Postal Progress League addressed the convention briefly, by permission, urging the association to

take action in endorsing certain bills now before Congress for a parcels post.

Tuesday Morning Session

The first order of business was the report of President Van Cleave. He reviewed the labor legislation of the past 12 months, enlarged upon the efforts made in the presidential nominating conventions of last year in regard to anti-injunction planks, and warned the association that renewed attempts would be made in the December session of Congress to introduce and pass legislation inimical to the interests of manufacturers. Then followed the report of the treasurer, showing a satisfactory condition of the finances of the association, and the report of the secretary showing that the net increase in membership for the year had been 127.

Two committee reports were received; namely, on fire protection and on interstate commerce. In regard to a uniform bill of lading and uniform classification, recommendations of former reports on interstate commerce were reaffirmed, and the following statement made: "A bill of lading plan devised by representatives of the shipping public, the banks and the railroads promulgated after approval by the Interstate Commerce Commission is now in use. The difficulty in the way of classification was greater, but a select body of expert traffic officials has been engaged since January, 1908, in the endeavor to reach a solution, and the sincerity of the railroads seems proved by their expenditure of $100,000 per year on the work of uniform classification."

Proposed increased taxation and our $100,000,000 deficit were characterized as the "direct result of national extravagance" and following "a mad excitement of military spirit." "Yet no true political economy can afford to neglect moral principles. By far the cheapest way of overcoming our enemies is not to have them. Customers pay many times better than enemies."

With reference to the steel schedules as they now stand in the tariff bills under consideration at Washington, we read: "On the one hand the duties on crude material in steel might quite safely, and to the advantage of the general manufacturing interest, have been still further reduced. On the other, the revenue needed to restore the $100,000,000 deficit could have been in a considerable measure made up from moderate duties on tea and coffee, of which the consumer need be hardly conscious, and by an inheritance tax recommended by the President."

Former recommendations for extensive improvements in our waterways were repeated, three projects being specifically mentioned: First, a deep water communication from the Gulf by the Illinois and Chicago rivers to Lake Michigan; second, an interior, still-water way between Massachusetts and South Carolina; third, a ship canal from Lake Erie to the Hudson, and thence to the Ocean by way of Lake Ontario and the Mohawk river and connecting canals. Issuing of bonds was suggested as a proper means of obtaining funds for these great improvements, in order that the costs thereof might be distributed over the present and future generations in accordance with the benefits derived.

The committee on fire protection advocated the enactment of a fire-marshal law in the 35 States which have not yet adopted such legislation. A proper fire-marshal law, the committee stated, could "by publicity and education on the one hand, general State regulations on the other, and finally through pressure on the municipalities through different channels, produce a distinct betterment of fire-waste conditions in any State in this country."

The address of the morning was given by S. B. Scudder, of the International Banking Corporation of New York City, who spoke on the opportunities of the manufacturer in foreign fields.

Tuesday Afternoon Session

An address presented by Thomas E. Durban on desirable improvements in interstate trade was read by the secretary in Mr. Durban's absence. Attention was called to the lack of uniformity in State laws dealing with so-called foreign corporations, and the statement was made that in regard to certain lines of manufactured products a distinct hardship is placed upon the manufacturer because he must build apparatus to meet a wide variety of specifications incorporated in the laws of the various States. "We think that there is no subject that the National Association of Manufacturers can take up that is as important to their welfare as the uniform law of corporations and establishing the right of corporations to do business throughout the United States. The relation of trade between States is of more importance to the manufacturer, if possible, than the relation of trade between countries. Our home market is the most desirable market we have, and the freer exchange of trade we can have among ourselves at least, the better it is for manufacturers.

"The idea of regulating trade in various States, not only appertains to corporations in general, but in our particular case, we being manufacturers of boilers on a large scale, is directed particularly in many States at our specific trade. For instance; the various States in the Union have enacted laws governing the matter of steam boilers, stating the quality of material to be used, the thickness of the material, and the manner in which it shall be worked or put together, and in no two States are these laws similar; so that a general contractor or general manufacturer who finds it necessary to locate branch offices in various States is confronted by the fact that he must have boilers built to conform to the various laws of the States, and a boiler that would fully comply with the requirements in New York State could not be used in Massachusetts, and one that could be used in Massachusetts could not be used in Pennsylvania, etc."

F. R. Boocock, secretary of the American Anti-Boycott Association, addressed the convention on "Law and Reason, Labor's Two Best Friends." The trend of this address is sufficiently indicated by the title.

Then followed reports of the committees on merchant marine and on forests and waterways. The committee on merchant marine, after succinctly stating the present condition of American shipping and its decadence since the days of President Madison, took up the two remedies that have been generally suggested; namely, differential duties and ship subsidies, analyzed both, stated its belief that differential duties are impracticable and strongly advocated the enactment of national legislation providing for ship subsidies. A pertinent paragraph dealing with the future use of the Panama canal is: "We are building the Panama canal which will cost from $300,000,000 to $500,000,000 without a ship at the present time to go through it. We have a few Trans-Atlantic ships with a moderate mail compensation, but none that would use the Panama canal. Therefore, we are building the canal to give Germany and England better facilities for their magnificent merchant marines and for the extension of their trade. What an anomalous position the United States Government occupies! It maintains a fighting navy at a cost of $130,000,000 a year, and no ships for transports in case of war. It builds a canal at a cost of $300,000,000 or more and not a ship to go through it."

The report closed with the following resolution: "Resolved, that the association recommend to Congress the passage of a bill like that under consideration at the last Congress and advocated by President Taft, providing for sufficient postal compensation to enable a swift and regular service in American steamships to the principal countries of South America and to the ports of Australasia, Japan and the Philippines."

The report of the committee on forest and waterways reaffirmed a previous recommendation for the immediate repeal of the timber and stone act, and suggested the building up of a body of men in the interests of the forest service, to be called upon for military duty whenever occasion arose; at the same time suggesting that the regular army and national guard should be called into service whenever disastrous fires threaten any of the forests in any part of the United States.

The most general and animated discussion of the session, in fact of the convention, took place on the report of the tariff committee. The report declared for the idea of a permanent tariff commission and

prophesied that a bill providing for such a commission or board would be passed within a few weeks. A certain amount of vigorous opposition developed against this idea, which has been supported by the association for the last two years. Finally a compromise was effected in favor of the suggestion that the President be authorized to employ from time to time experts to make such investigations of manufactured articles as he may see fit. Instructions were given to prepare a resolution embodying the desires of the convention in regard to tariff legislation.

Wednesday Morning Session

This session was given over to committee reports. The Committee on Bankruptcy commended the national bankruptcy act of 1898 as the best law in its field which has ever been on the statute book of the United States and presented the following resolution:

"Resolved, That the National Association of Manufacturers will, as in the past, combat all attempts to repeal this act or to weaken it in any essential particular, regardless of the quarter from which the act is assailed or the pretext on which the assault is based; and, be it further

Resolved, That the operation of this act has shown that in some details amendments ought to be made so that it would more fully meet the business demands of the day; and, be it further

Resolved, That the National Association of Manufacturers stands ready to coöperate with every other industrial or commercial organization which seeks to amend the law along conservative and progressive lines."

The Committee on National Incorporation outlined two courses of action which at least seem worthy of consideration. First, the accomplishment of the desired result by federal enactment of some legitimate scheme of permissive national incorporation; and, second, the accomplishment of precisely the same result by a rational, intelligent and common-sense plan of uniform State legislation. After discussing these two plans and stating that many lawyers versed in constitutional law question the constitutionality of a national corporation act, the report closed with the following recommendation: "Our recommendation, therefore, is that the matter of securing a progressive scheme of uniform State legislation with respect to laws affecting manufacturing interests in their various and manifold features be referred to the counsel of the association with instructions to lend what moral support our association can give toward those who are laboring in behalf of the problem that needs urgent and intelligent solution."

The report in regard to pure food was decidedly optimistic in tone. "Your committee is able to report a marked improvement in the grade of food products as noted by the statements upon packages. It has been your committee's belief that the fundamental principle of labeling is to require fair, plain and honest statements so that buyers can readily inform themselves as to the contents of packages. This, of course, can only be had through the statements on the labels. The committee expressed its approval of the reappointment of Secretary Wilson, of the Department of Agriculture, and recommended to the association that it render every support to the secretary in working out the provisions of the Pure Food and Drug Act."

The Committee on Immigration said: "There can be no denying the statement that proportionately our immigration does not come from as desirable sources as in earlier times; that is, the aliens that come to us now being so different from the original stock cannot so readily be assimilated into the body politic. Moreover, those now coming do not, to as great an extent as in the earlier times, become attached to the soil, but go into occupation to which they have been but illy, if at all, adapted. Your committee, therefore, recommends that you coöperate with the commissioner general of immigration in the passage of any laws that tend to raise the personnel of immigrants; that every effort be made to exclude the dangerous element of secret societies; that we favor selection rather than restriction of immigration; that the contract and labor law be impartially enforced and every effort be used to divert immigration from the larger seaport cities to the interior, and that assimilation of immigrants be made a matter of careful research."

A number of resolutions were adopted. That on patents referred to the discrimination made against foreign inventors in several European countries, in that the inventor is compelled to work his patent in the country in which it is patented, or run the risk of having it revoked. Congress was urged to take steps whereby American inventors can be freed from these undesirable provisions through suitable treaty agreements. Resolutions on the merchant marine, industrial education, forests and waterways, fire prevention and the tariff were in line with the discussion and committee reports that have been referred to in preceding paragraphs. In view of the enormous amount of engineering work now being carried on by the United States Government in the improvement of harbors and rivers, and the reclamation work in the West and South, a memorial was indorsed to be presented to Congress suggesting the establishment of a new national department of the Government to be known as the Department of Public Works.

Another resolution touched upon the question of newspaper and periodical advertising which stated that such advertising is a commodity to be both bought and sold, and that publishers should furnish accurate information as to their circulation and should establish and maintain uniform rates for uniform service rendered.

Wednesday Afternoon Session

The speaker of the afternoon was James A. Emery, special counsel of the Council of National Industrial Defense. His subject was "Legislation Affecting Labor Troubles," and his address reviewed attempted anti-injunction legislation of the past 12 months in both the National Legislature at Washington and various State legislatures.

The election of officers resulted in placing John Kirby, Jr., of Dayton, O., in the president's chair. In briefly outlining his policy in his inaugural address President Kirby said: "My policy is the policy of David M. Parry and James W. Van Cleave." Retiring President Van Cleave received several gifts as tokens of the appreciation with which he was held by his associates and members of the association. These were a bronze placque, a check for $10,000, a ruby and diamond scarf pin, a diamond ring and an association badge set with diamonds.

The social feature of the convention was the reception and banquet of Wednesday evening. Count Von Bernstorff, German ambassador, spoke in defense of the doctrine of mutuality in foreign trade. He expressed a hope that Germany might negotiate a new commercial treaty with the United States as present agreements would be abrogated after the passage of the impending tariff bill. He stated his belief that commerce is reciprocal and based on fair exchange and mutuality and expressed the hope that the trade between the United States and Germany might be on a basis of fair exchange.

In reply Congressman Charles N. Fowler said: Let us be careful lest in establishing mutuality we give away our own market of $25,000,000,000. You should be very careful before you make a move that it is really to your advantage, and remember that the home market is our own, and it is better to have a home market of $25,000,000,000 than to be sharing in a foreign market of $10,000,000,000, for which every nation in the world is a competitor."

A new brake, designed to bring vessels traveling at a high rate of speed to a quick stop, is soon to be given a test on the battleship, "Indiana." The inventor of the device claims that it will bring a vessel running at the rate of 20 knots an hour to a full halt in a few seconds, and the Navy Department has issued orders for the experiment to take place. The device is made up of two large wings, fastened by hinges to each side of the ship below the water line, which, when not in use are held close to the ship's sides, and are 13 feet high and 6 feet wide. When the stop is desired the wings are forced open by means of hydraulic power, until they are at right angles to the sides.

Radius Milling Mhines

The engravings illustrate two special radius milling machines built by the Newton Machine Tool Works, Inc., Philadelphia, Penn. One of these machines, as shown in Figs. 1 and 2, is equipped with horizontal spindle; the other, Fig. 3, has a vertical spindle and the work is held horizontally as illustrated.

The construction of the horizontal machine is clearly shown in Fig. 1, and the method of operating will be understood from Fig. 2, which shows the machine milling turbine work. The spindle of this machine is 5 inches in diameter and is driven by a sleeve revolving in a brass bushing (having a parallel internal and a taper external bearing with adjusting nuts to compensate for wear) in the rear of the upright. The front bearing of the spindle is also of bronze with taper external and parallel internal bearings with adjusting nuts to compensate for wear. The spindle sleeve is driven through intermediate spur gearing by a General Electric type "CQ" continuous-current variable-speed 10-horsepower motor running at from 350 to 700 revolutions per minute. The cutter arbor is supported by the yoke shown on the table and also revolves in a brass bushing having the same form of bearing and adjusting nuts as the spindle and bushing referred to above. The cutter arbor is driven by a broad-face key and is held in the spindle by a through retaining bolt. For convenience in setting the cutters to the work, the spindle has hand adjustment operated by the two hand wheels shown in Fig. 1, on the back of the spindle, one for the adjustment and the other for locking the spindle securely to the sleeve.

There are two saddles mounted on the upright. The upper one carries a trunnion on which the swinging arm is mounted and the lower one has a compound slide arranged to travel horizontally, carrying the swinging arm (on which the fixtures holding the work are mounted) past the cutters. The upper saddle has a vertical adjustment for the different length of radii and is held to the upright by a double taper shoe always adjusted to a sliding fit. There are eccentric levers provided for clamping the saddle rigidly to the upright after the final adjustments have been made. For minute adjustments of the cut, the nut shown in Fig. 2 is used. Three changes of friction-geared feed are provided through the train of gears shown at *A*, Fig. 1, and also power fast traverse, both of which can be reversed if a double-throw switch is used in connection with the motor.

In operating this machine, the various radius fixtures are clamped to the bottom of the swinging arm, as shown. The arm is adjusted to the left and the work mounted in a fixture, after which the arm can be brought to the cutters by hand or by the fast traverse motion, and the cut taken by the power feed which is more clearly seen in Fig. 1, which shows the compound slide on the bottom saddle. To insure rigidity while taking these cuts, the knee shown on the table is adjusted against the swinging arm giving the arm a substantial front and rear bearing. All adjusting screws are fitted with gaging devices giving measurements varying by

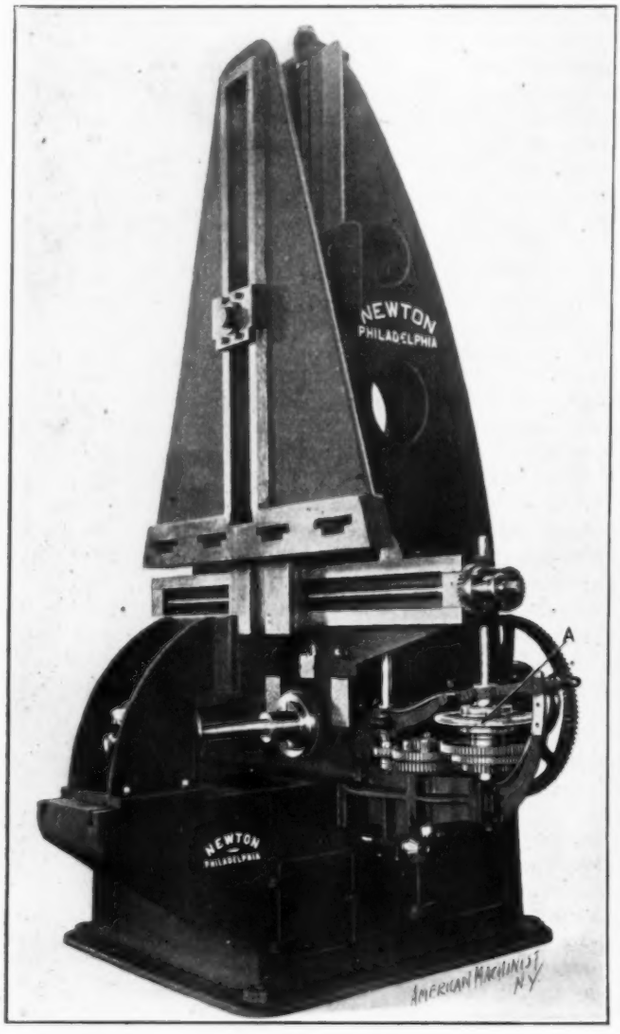


FIG. 1. RADIUS MILLING MACHINE WITH HORIZONTAL SPINDLE

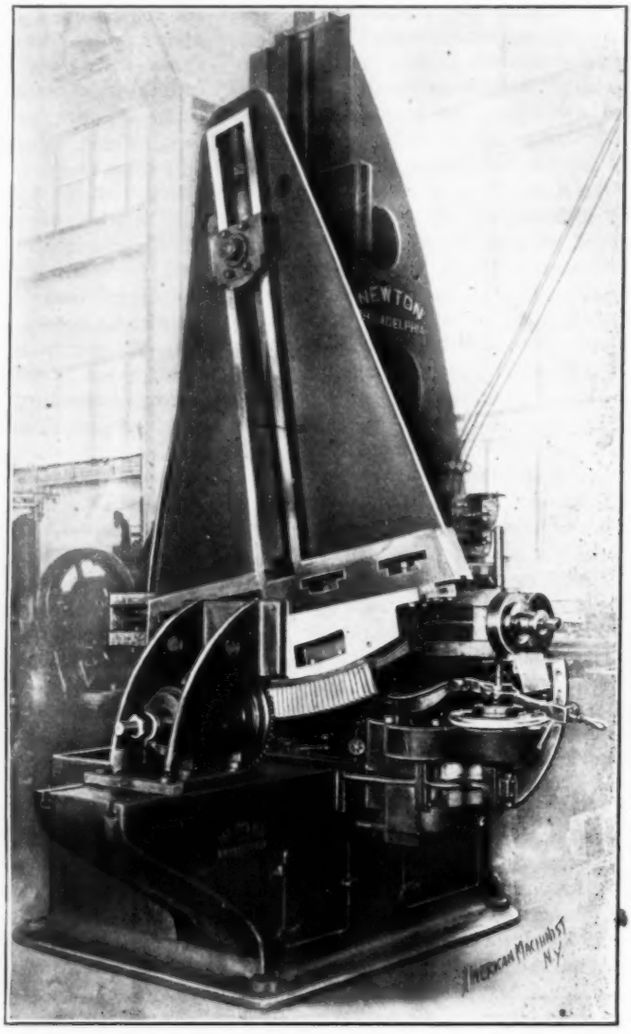


FIG. 2. RADIUS MILLING OPERATING ON TURBINE WORK

0.0005 inch. The machine is equipped with pump, piping and attachments for lubrication. It has capacity for arcs up to 68 inches in length and radii up to 100 inches.

Hardening Steel

By E. W. Harris

Very interesting are some of the ideas expressed by recent contributors on such a hackneyed subject as hardening steel; interesting because the fundamental points in the subject still remain a mystery, and while such is the case the last word cannot be said upon it. There seems to me, however, to be sufficient definite knowledge on the subject to warrant a systematic tabulation of facts with methods of applying them in a concise form. The purpose of this article is to suggest lines upon which such a system may be worked.

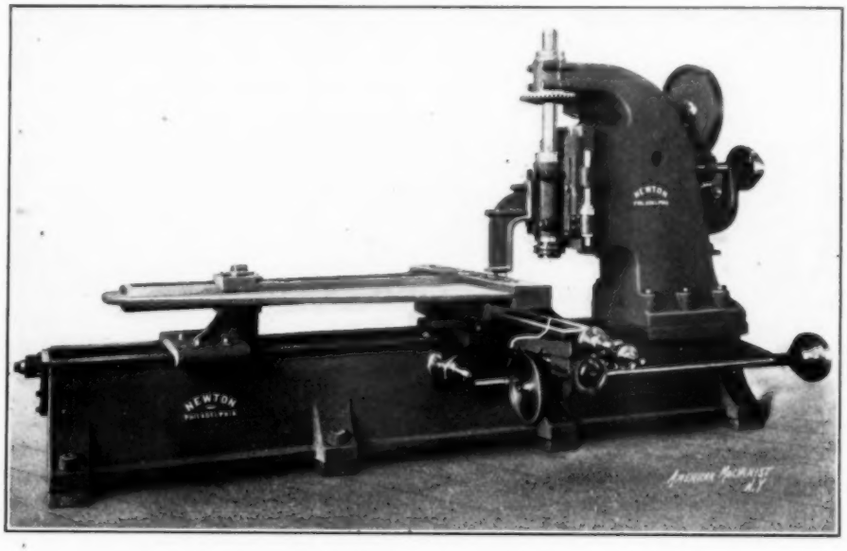


FIG. 3. RADIUS MILLING MACHINE WITH VERTICAL SPINDLE

Having arrived at the fact of there being a critical point in the heating of high-carbon steel, we have also proved that at that point, or immediately above it, such steel will harden to the best advantage, but we still resort to the haphazard methods of deducing cause from effect, which means, in this case, finding the critical point by quenching at certain known, or often unknown heats. This way is, of course, necessary when the experimental stage is not yet passed, but we appear now, to have arrived at a stage when we can advance some.

We know that the greater the density of the carbon content of steel the lower is the critical point at which it will harden, using for our purpose clear, cold water as a quenching medium. From this arises another fact that steel must contain a certain proportion of carbon to be capable of hardening at all, at any heat. Now if we are to use the most widely accepted theory that the carbon changes at a certain temperature and acts upon the steel when quenched, it is reasonable to suppose that the volume of carbon in a low-carbon steel is too weak to act upon it; and with a steel which takes quite a high temperature comparatively, to harden the density of the carbon is sufficient to harden if it can gain freedom enough in the steel, which I presume the action of the molecules of metal allows it to do under high heat.

As to the quenching part of the process, it is the common experience that the quicker the heat is removed from the metal the harder it will become. This being the case a solution of salt and water will be the simplest if not the most efficient base to work from.

With these facts before us I would suggest that a standard be originated on similar lines to the following: Let all tool steel be marked with its approximate percentage of carbon before it leaves the manufacturers. In conjunction with this let our laboratory experts draw up a chart or table stating the "critical point" of heat ascertained for each known quality of steel, with brine as a quenching medium. This matter can form, with probable improvements, the basis of the chart or table.

We are confronted with the fact at this stage that other quenching mediums are used besides brine with results varying according to the articles to be treated. With many of these secret fluids our theory of the quickest transmission of heat may not agree; most of the acids used for this purpose probably act upon the changed carbon as a kind of stimulant. Howbeit, we know it is necessary to use these fluids by which the quenching can be done upon a comparatively low heat, thus avoiding somewhat, distortions, fractures and the like.

Realizing this, the table suggested above can be supplemented by the critical points fixed upon to harden in a variety of chosen liquids. A data sheet so constructed I think would fill a real need in these hustling times.

Bearing in mind the facts presented above, it will now be observed that the so-called critical point varies in the same piece of metal according to the quenching fluid used; thus we have no constant critical point. It does not seem unfeasible to presume that, seeing that a certain quality of steel will harden in mercury at a temperature just luminous in the dark, a definition of a constant critical point should be taken from the foregoing fact.

Using this idea as a base, our laboratory experts could perhaps devise certain suitable fluid solutions for the various qualities of material; strengths, toughness, etc., must not be lost sight of, however. Thus we entirely reverse the older operation of finding the cause through the effect, for instead of finding a heat at which some steel will harden, we find solutions that will harden all steels intended to be treated at one heat.

It may not be irrelevant to the subject of this article to mention a case of peculiarity in steel that I recently came across. A 2-inch mandrel turned from bar steel was packed for case-hardening in the usual way with a number of others. After quenching, this particular piece proved to be not hard. It was reheated and again quenched with no better results. This was a puzzle, for we have proved that it it the best practice to allow packed articles to cool out before quenching and to reheat to quench for hardening at a fairly low heat—a much finer grain can be obtained by this method than can be got by quenching straight out of the box.

It was decided to repack the piece, and this was done with special care, but these efforts resulted again in disappointment for the piece was not hard enough. By this time the amount of material left for grinding to size had vanished, and it was condemned as spoiled. However, it was annealed so the turner could reduce it to a size smaller; and—this is the most astonishing thing—it came out of the annealing so hard that the turner could not touch it.

It is well known that during the past year or more of depressed trade conditions the automobile industry has suffered, contrary to what would naturally be expected, very little owing to such depressed condition. According to the statement of a high official in the Licensed Association of Automobile Builders there was actually spent for automobiles during the year 1908, $122,000,000, and this taken together with the amounts disbursed for the accessories sold, repairs, and other expenses met with in the operation of cars, justifies the estimate made by the same official that the automobile industry was responsible for the circulation of very nearly $500,000,000 during 1908.

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The Cost of Repairs to Machines and Tools

In many shops the cost of repairs to machines and tools is almost an unknown quantity, as practically no record of it is kept except to charge it up to general expenses. When a machine breaks down, or a tool goes out of commission, they are repaired if possible, and little or no attention is paid to the loss of earnings from the machine, and too often, even the cost of repairing is unknown. It is looked upon as an expense that must be met and so why bother with it?

But the shops that do "bother" with such things often find out some interesting things that save dollars in later years. They find that the result of a little carelessness or want of forethought may cost many dollars and even though the offender be discharged, the cost of the repair remains just the same.

Those who have studied the repair question to a considerable extent, are inclined to lay more stress on ignorance than carelessness and to blame themselves to some extent for not paying more attention to the proper instruction of both men and boys when a new tool is put in the shop. Men who are not accustomed to gear-driven machines can hardly be blamed for going astray if left to their own devices; as some of them are decidedly puzzling to an untrained man. A few minutes' careful instruction in such a case will often save dollars in repair bills, especially in the case of an apprentice. And it is an open question whether it is not better to keep a man who has had an accident to a machine than to try breaking in a new one, as, unless he has lost his nerve completely, he is very apt to be a better man than the average. It is expensive training, but often very effective.

Then there is the question of lubrication, which has been touched on before, and which is believed to be the cause of too large a percentage of repairs. But whatever the cause, it will pay to watch the repairs more closely than is apt to be the case, and it will be found that many of them can be reduced quite materially by instruction as to the proper use of both machines and small tools. While this may seem self-evident to all who are skilled mechanics, it must be remembered that many men work in the shop from force of circumstances and not from any natural aptitude in this line of work. These are the men who are responsible for many accidents that result from lack of knowledge, but the real responsibility lies in the failure to properly instruct the men who are to operate the machines. A little care in this direction will save many dollars in repair bills in the course of a year and well repay the time and trouble it may seem to be.

It has been suggested, and it seems to have many good points, that boys be employed on repair work to some extent as well as upon the regular work of the shop. This not only gives a variety to their work, but also allows them to become familiar with the construction of the various machines, points out the weak spots and the damage that may be done by careless handling. It should prove an object lesson that will make a lasting impression and tend to prevent similar accidents in the future.

Smoke Prevention is Possible

A bulletin on the Smokeless Combustion of Coal, prepared by D. T. Randall and H. W. Weeks, is about to be issued by the Technologic Branch of the United States Geological Survey. Between 400 and 500 industrial establishments have been inspected in 13 of the largest cities of Indiana, Illinois, Kentucky, Maryland, Michigan, Missouri, New York, Ohio and Pennsylvania and from 284 of them sufficient information has been collected to form the data of this report. It is shown plainly that bituminous coals high in volatile matter can be burned without smoke; that large plants carrying fluctuating loads can be operated without producing objectionable smoke. The necessary factors are proper equipment, efficient labor and intelligent supervision.

It has long been contended, and rightly so, that smoke prevention is possible and it is nothing short of a disgrace that some of our most progressive cities allow the surrounding atmosphere to be polluted by smut and smoke from the stacks of industrial plants. Smoke prevention is possible; yet the work of educating the public to a realization of this fact, and the corollary that it is possible to rid our cities of the smoke nuisance has been difficult, protracted and thus far only partially successful. The facts and conclusions presented by this bulletin are cumulative rather than new, yet they should serve an excellent purpose in once more showing the public that they can have cities free from smoke if they will, and showing manufacturers that cheap patented additions to poorly constructed furnaces lead to inevitable failure. The principles surrounding smokeless combustion are not abstruse. They are easily appreciated, easily applied in practice and the result is abatement or elimination of one of the most unsightly, disagreeable and unnecessary factors in American life.

Valuable general conclusions are presented by Messrs. Randall and Weeks. We read: "Smoke prevention is possible. There are many types of furnaces and stokers that are operated smokelessly.

"The value of this smokeless requirement to the average purchaser lies in the fact that he is thus reasonably certain of good installation. A good stoker or fur-

nace poorly set is of less value than a poor stoker or furnace well set. Good installation of furnace equipment is necessary for smoke prevention.

"Stokers or furnaces must be set so that combustion will be complete before the gases strike the heating surface of the boiler. When partly burned gases at a temperature of say 2500 degrees Fahrenheit strike the tubes of a boiler at say 350 degrees Fahrenheit, combustion is necessarily hindered and may be entirely arrested. The length of time required for the gases to pass from the coils to the heating surface probably averages considerably less than one second, a fact which shows that the gases and air must be intimately mixed when large volumes of gas are distilled, as at times of hand firing, or the gas must be distilled uniformly as in a mechanical stoker.

"No one type of stoker is equally valuable for burning all kinds of coal. The plant which has an equipment properly designed to burn the cheapest coal available will evaporate water at the least cost.

"Although hand-fired furnaces can be operated without objectionable smoke, the fireman is so variable a factor that the ultimate solution of the problem depends on the mechanical stoker, in other words, the personal element must be eliminated. There is no hand-fired furnace from which, under average conditions, as good results can be obtained as from many different types of mechanical stokers, and of the two equipments the one that will require the least attention from the firemen gives the best results. The most economical hand-fired plants are those that approach most nearly to the continuous feed of the mechanical stoker.

"The small plant is no longer dependent on hand-fired furnaces, as certain types of mechanical stokers can be installed under a guarantee of high economy with reduction of labor for the fireman.

"In short, smoke prevention is both possible and economical."

The last sentence of the above quotation is striking and should be considered by owners and operators of coal-fired boiler plants and by the general public as well. It shows the possibility of clean cities, of clean surroundings for manufacturing plants and the accomplishing of results that will tend to aid in the conservation of our fuel resources. Any community that will, can rid itself of the disgrace of a smoke-laden atmosphere and of a layer of grime and soot on all exterior objects; for the principles of combustion are known, the necessary mechanical devices exist, the engineering application is available. These factors properly united can produce furnaces that will burn coal with smokeless combustion, "in short, smoke prevention is both possible and economical."

New Publications

FORGING. By John Lord Bacon. 106 6x9-inch pages; 175 illustrations; indexed. American School of Correspondence, Chicago, Ill. Price, $1.

This is an elementary book on forging and tempering, written as a textbook for home study. There are three main divisions: "Materials and Tools," "Typical Forging Operations" and "Miscellaneous Forging Processes." The general smith's tools are illustrated and described, simple forging is shown, the making and dressing of the common machine-shop tools is treated, the common power-driven forge-shop tools are described, and lastly, a section is devoted to a reprint from *Cassier's* of an article by Prof. Elihu Thomson on "Electric Welding." The work is fairly well written, is practical and should be of service to the student or apprentice of blacksmithing.

HEAT ENERGY AND FUELS. By Hanns v. Jüptner; translated by Oskar Nagel. 301 6x9-inch pages; 118 illustrations; indexed. McGraw Publishing Company, New York City. Price $3.

The author is professor at the Imperial and Royal Institute, Vienna and has written this work as a text book for students and as a handbook for the practising engineer. Thus it gives not only fundamental principles but also the latest experimental data and practice. Among the topics of greatest interest are measurement of high temperatures and recent data on the melting points of various substances; discussion of incomplete combustion at constant volume and constant pressure, and a great amount of information on solid, liquid and gaseous fuels and their production. The chapter on the gasification of fuels is of especial value. The tabular data are abundant, conveniently arranged and constitute one of the most useful features of the work. A brief digest of the chapter headings is: Pyrometry; Combustion Heat and its Determination; Incomplete Combustion and Combustion Temperature; Fuels—wood, peat, brown coal, bituminous and anthracite coal, charcoal, peat coal, coke; Coking Apparatus; Liquid and Gaseous Fuels; Producer Gas, Water Gas, Dowson Gas, Blast Furnace Gas and Apparatus for the Production of Fuel Gases. The book can be justly recommended to anyone interested in heat, fuels and combustion.

MACHINE DRAWING AND DESIGN FOR BEGINNERS. By Henry J. Spooner. 226 9x6¾-inch pages; 751 illustrations in the text. Longmans, Green & Co., New York City. Price 75 cents.

This is stated to be an introductory work for the use of technical students; and it is far above the average of books of its kind and in its field. The selection of material is good; its style is simple and easy; definitions are clearly worded; mathematical equations and formulas are in a usable form and the values or significance of the various quantities are stated in such a manner that they cannot be misunderstood. The only detracting feature from an American viewpoint is that it is founded on English practice and, therefore, differs from ours in regard to many details and standards. The first 6 chapters deal with the art of drawing and from them, with sufficient practice, an intelligent beginner should be able to learn to make simple working drawings. The remaining chapters deal with machine details. Most chapters have drawing exercises at the end for the aid of instructors. There are also many sketching exercises that should be commended. One of the weakest points in the work of the average mechanical draftsman is his free-hand sketching. A final feature that should be mentioned is copious notes referring to other works, or articles in technical publications, or transactions of societies, pointing the way for the student to extend his study, if he will, as well as indicating the source of the data.

Personals*

Walter V. Houck, formerly tool foreman with the Garvin Machine Company, has been appointed general superintendent of the Hartford Suspension Company, Jersey City, N. J.

Edward Schwartz, formerly general superintendent, Antwerp Telephone and Electrical Works, Antwerp, Belgium, has returned to this country, and for the present, has located in Chicago, Ill.

C. E. Holgate, who, for the past ten years has filled the position of assistant to the general manager, and in charge of the sales department of Gould & Eberhardt, Newark, N. J., has resigned to take charge of the automobiling department of a daily paper in that city.

John J. Harman, a mechanical engineer with a varied experience, including service in the United States Geological Survey, and instructor in machine design at the University of Illinois, as well as having been connected with the Link-Belt Company and the Acme Harvester Company, as chief draftsman, has become a member of the Harman Engineering Company, civil and mechanical engineers, with offices in Peoria, Ill.

Dwight T. Randall, until recently engineer-in-charge of fuel tests, technologic branch, United States Geological Survey, has associated himself with the Arthur D. Little Laboratory of Engineering Chemistry, of Boston, in charge of the department of fuel engineering. Mr. Randall was formerly connected with R. W. Hunt & Co.; and Westinghouse, Church, Kerr & Co., and later in charge of the steam-engineering laboratory of the University of Illinois, and of steam and boiler tests at the St. Louis Exposition.

*Items for this column are solicited.

New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make it Possible To Do Better Work at a Reduced Cost

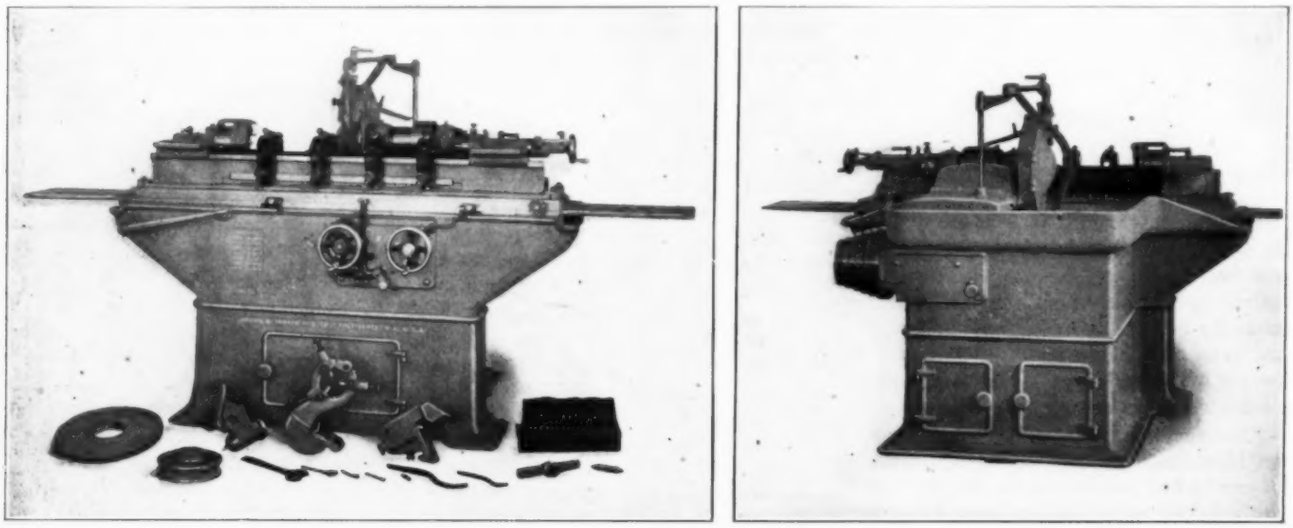
THE LATEST INFORMATION

Plain Grinding Machine

A new plain grinding machine brought out by the Brown & Sharpe Manufacturing Company, Providence, R. I., is illustrated in the accompanying engraving. This grinder, which is known as the "No. 12," embodies a number of features of interest. A feature of special importance is the complete separation of work speeds and table feeds. By this arrangement it is possible to obtain a correct table feed for any work speed, thus, when it is desired to remove stock rapidly, a slow speed and fast feed are available. Any of the changes of feed or speed can be made without stopping the wheel, work or table. In the front view a lever is shown at the left for starting and stopping that part of the overhead works which feeds the table back and forth and also drives the work-driving pulley on the headstock. This lever replaces the shipper arm generally employed for this duty and changes from the tiresome horizontal movement over the operator's head to a vertical movement in front of the operator near where his hands would naturally be in operating the machine. As this lever is moved every time a piece of work is calipered or removed from the machine, the relief to the operator becomes quite a factor in increasing the output of the machine.

The reversing mechanism, which allows work to be ground close to a shoulder, embodies the well known "load-and-fire" principle of construction with the additional feature of automatically stopping the work-carrying table at its reversing point when the automatic stop mechanism has been set in operative position at any time during the traverse of the table. The cone seen in the rear view operates the work table through suitable gearing and clutches, the reversing mechanism being controlled from the front of the machine by a lever reciprocated alternately by reversing dogs carried by the table. Pressure applied by the operator on the knob in front of the hand wheel during the last traverse of the table before it is to be stopped brings the hand wheel, which is standing still during power traverse of the table, into operative connection with the table-traverse mechanism by means of clutch teeth, and when the table comes to the reversing point it is automatically stopped. Several advantages are obtained by the table-traverse hand wheel standing still during the power movement of the table. The nature of the operation of grinding requires the operator to stand close to the machine for the delicate adjustment of rests, etc., during the movement of the table; the inconvenience and danger during this operation, due to a revolving hand wheel and protruding handle are here done away with. The hand wheel is necessarily geared up to give an easy and accurate movement to the table when facing a shoulder on a piece of work; this gives a comparatively high speed to the hand wheel and its momentum is a serious factor when reversing the direction of the table-feed mechanism. Therefore, as the table hand wheel never reverses, it can be of much larger diameter. The mechanism for connecting the hand wheel to the table-traverse mechanism does not require another operation besides that which the operator necessarily takes to stop the machine, therefore there is no more time consumed in operating the machine, nor is the number of levers, knobs, etc., increased.

The table-traverse mechanism mounted on the front plate shown, also includes a fast and slow change of speeds suitable to change from a traverse speed correct for roughing out work to a correct speed for finishing. This change of speed is made by shifting a small lever, shown just above the right-hand hand wheel. The automatic cross-feed used on this machine is of the usual type employed on the Brown & Sharpe grinding machines, but has been provided with means for disconnecting the hand wheel (shown at the center of the machine) which is used for the fine feed of the grinding wheel toward the work. This leaves the wheel slide free to be moved quickly from one extreme of its travel to the other, thus thoroughly distributing the lubrication under the ways of the wheel slide. This has been found very important as it is only when these bearings are thoroughly lubricated that it is possible to get the movements, often as fine as 0.000125 inch, that are required. This quick movement which is obtained by the hand wheel, shown just above the cone pulley in the rear view, serves also to change the position of the grinding wheel quickly for different sizes of work.



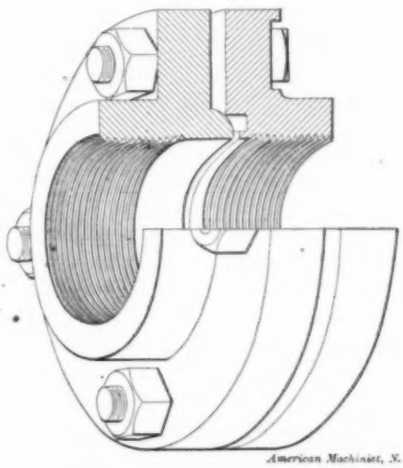
BROWN & SHARPE NO. 12 PLAIN GRINDING MACHINE

The wheel-carrying slide is gibbed to the ways by a gib which is carefully fitted to position by scraping and drawn firmly into position by bolts, thus preventing the possibility of the operator clamping the slide by tightening the gib screws. If after years of service it becomes necessary to compensate for wear of the sliding surface, it may be readily done by removing the gib and scraping its upper surface. The spindle which carries the grinding wheel runs in phosphor-bronze boxes, is of one diameter throughout and of heavy proportions for this size of machine. An oil chamber around the bearings supplies abundant lubrication; these bearings are self-alining and adjustable for wear. The thrust of the spindle is taken by two convex washers which insure proper alinement with the spindle. The headstock is very heavy and rigid, and attention may be called to the wide belt provided for driving as indicated by the pulley shown in the engraving. The work is carried on dead centers mounted in the headstock and the footstock. The headstock and footstock slide on ways on the swivel table and are clamped by levers, as shown in the front view, which also shows the universal back rests which are capable of delicate adjustments and used for supporting long, slender work or splined shafts.

The machine rests on three bearings on the floor. The water tank for the machine has a capacity of 18 gallons. The pump is of the vertical type employed on all the grinding machines made by this company, the pump bearing being above the level of the water. The general proportions of the machine are such as to adapt it for grinding lathe spindles, milling-machine spindles, gear-cutter spindles, and, in fact, all heavy work within its capacity. It swings work up to 8 inches in diameter and 36 inches in length. The swivel table which rests on the sliding table, can be readily set at an angle with the ways for grinding tapers. The scale reads to 8 degrees and 3½ inches taper per foot. The six changes of wheel-spindle speed vary from 1200 to 2400 revolutions per minute and the 12 changes of work speed from 42 to 312 revolutions per minute. The 12 rates of table feed range from 8 to 100 inches per minute. The automatic cross-feed has a range from 0.00025 to 0.004 inch at each reversal of table. The wheels used are 16 inches diameter and 1 or 1½ inches face. The net weight of the machine is about 5050 pounds.

A Fitting for Heavy Work

The line cut shows a new flange union designed for heavy work. It is made of the very best quality of air-furnace malleable iron. It has a seat cut from drawn-brass tubing, so that it is free from sand or blow holes so common in cast brass. It is forced under pressure into an annular recess, after which a spherical seat is cut to receive the ball face of the opposite member. The faces are ground, making a tight joint under pressure as high as 3000 pounds.



A FITTING FOR HEAVY WORK

It will be noticed that the brass ring is set within the iron away from the inner bore of the fitting. It makes no difference in applying this fitting whether the pipes are in line or not. The joint is spherical and it will adjust itself to the pipe even though the pipe may be out of line by several degrees.

This fitting is being made in all sizes from 1 to 10 inches by the Jefferson Union Company, Lexington, Mass.

A Pipe Threading and Cutting-off Machine

Fig. 1 shows a machine having a capacity for threading and cutting off pipe from 2½ to 8 inches inclusive. The machine shown is belt driven, but can be readily changed to motor drive, using a constant-speed motor. Three-jawed independent chucks are provided on both the front and the rear spindle, the rear chuck being also furnished with flange grips for making up flanged work. This machine is all geared, ten distinct speeds being obtained by means of a gear box from a single driving pulley. The bore of the arbor is large enough to permit the passing through of extra-heavy 8-inch fittings. The oil pump, of the rotary type, gives a steady flow of oil.

Fig. 2 shows the sliding and floating die head arranged to slide on ways on the front of the die stand, allowing the head to move and accommodate itself to any eccentricity in the pipe. It also permits the head to be pushed out of the way for putting pipe in the front or rear end of the machine without injury to the chasers. The die head can also be pushed out of the way and clear the front chuck, permitting a cutting-off distance of only 3 inches for nipple work. The hand knob for making the die adjustments is directly in front of the operator, as is also the scale on the face of the cam ring.

The front ring is pivoted and can be swung open exposing the interior mechanism of the cam ring and die ring, and facilitates the withdrawal and insertion of

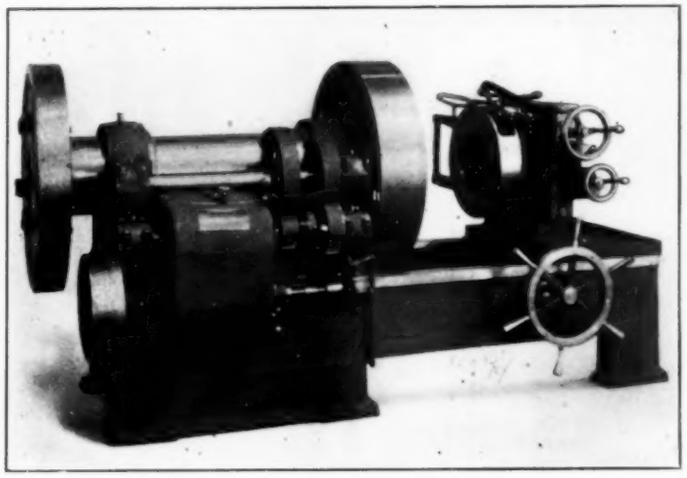


FIG. 1. 2½- TO 8-INCH PIPE MACHINE

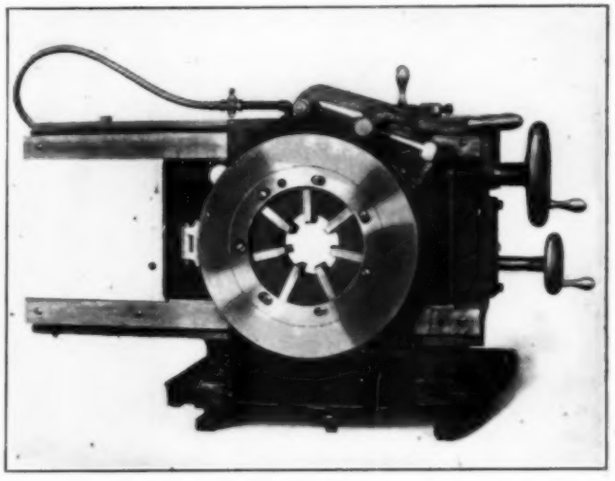
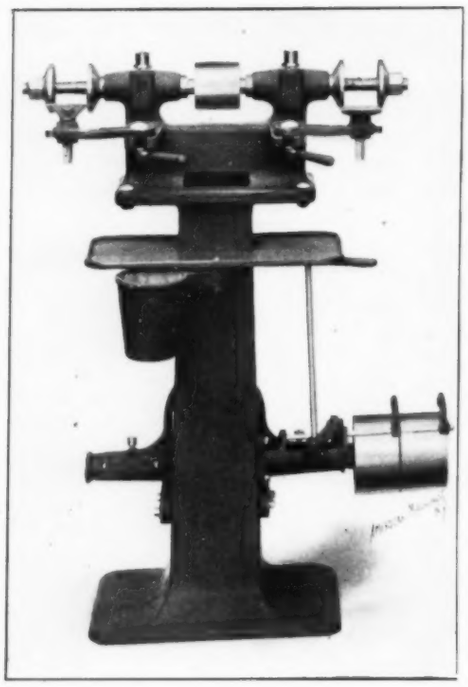
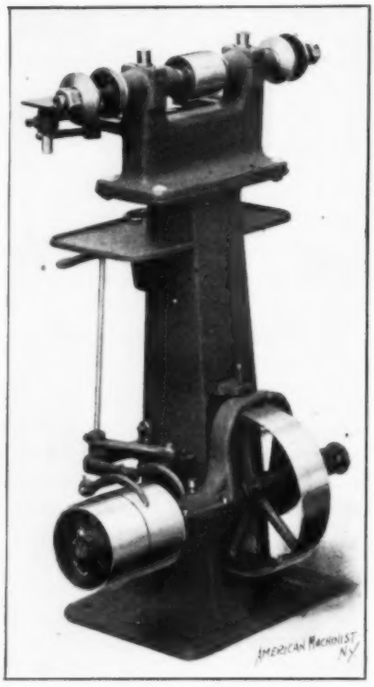


FIG. 2. THE SLIDING AND FLOATING HEAD



FRONT OF GRINDER



REAR OF GRINDER

chasers. The operator has the option of using the die head either opened or closed for removing or inserting the chasers. The cams are not made a part of the ring, but are of steel, each cam being separate and inserted into the ring, making replacement possible and not necessitating the closing down of the machine should a cam become worn or broken. The chasers are interchangeable and any one chaser in a set can be replaced without reference to the balance of the chasers.

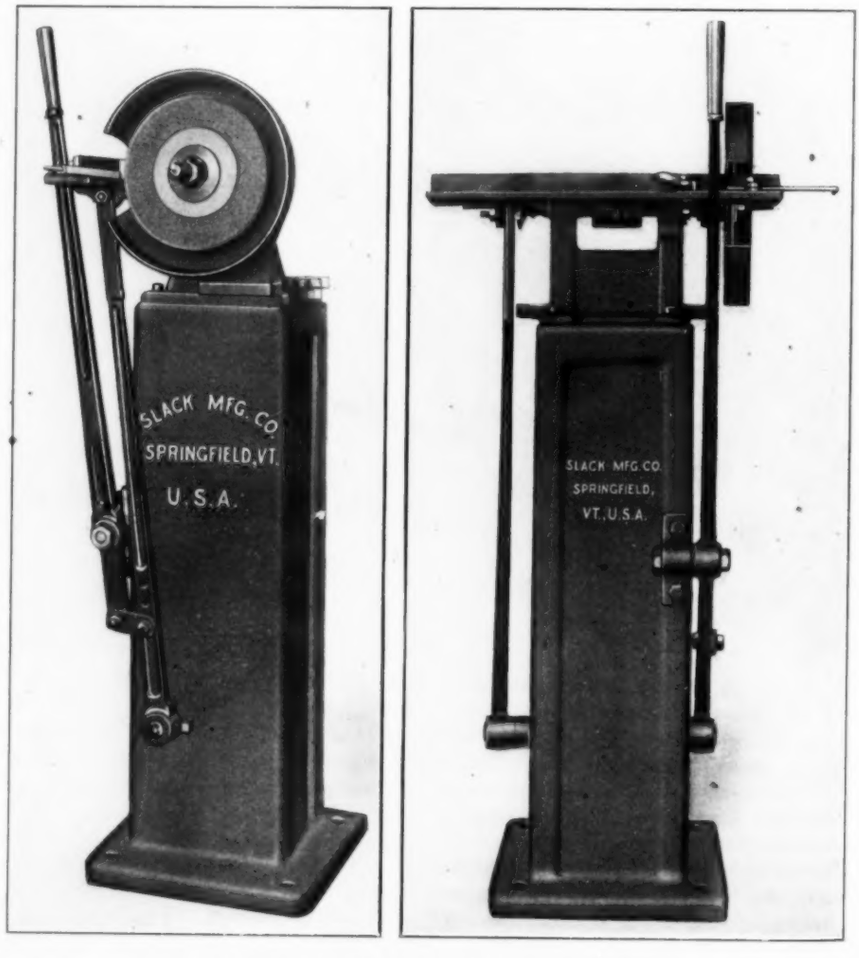
The machine is manufactured by the Stoever Foundry and Manufacturing Company, Myerstown, Penn.

A Grinder

The halftones show front and rear views of one size of a new line of grinding machines which are being built in five sizes by the St. Louis Machine Tool Company, St. Louis, Mo. In these grinders the arbors are of larger diameter than usual and are made of 0.50 carbon steel. They have square threads, two pitches coarser than standard. The boxes are lined with antifriction metal, are self-oiling, and are four diameters in length. The rest arms are curved, permitting a shorter fork than when straight rest arms are used, which is of advantage when large work is to be ground. The pan is 4 inches below the base of the machine, giving more room than usual. The machines can be had either with or without the self-contained countershaft shown. The lower halves of the boxes of the countershafts are cast with a lug. This lug is pivoted to the column. The top half of both boxes are cast in one piece, as shown, with a heavy loop passing over the driving pulley. This loop is provided with a lug which passes beneath the projecting lug on the column. The lug on the column is provided with an adjusting screw which forms a belt tightener. By loosening the two screws in the lugs at the rear of the column and screwing down on the adjusting screw, both the grinder belt and the belt from the line shaft are tightened simultaneously.

A Cutting-off Machine with an Abrasive Wheel

As will be seen, the base and head of the machine shown in the illustrations are very similar to those of small tool grinders now on the market. The cutting is done by a special abrasive wheel, made of carborundum, 11 inches in diameter by 3/32 of an inch in thickness which runs at a speed of 4000 revolutions per minute. The table of the machine is pivoted so that it will swing and is operated by a lever. The stock to be cut is secured to this table by means of a cam lever which holds it securely in place. Adjustable stops are also provided which gage the length and depth of cut accurately. The machine will cut any kind of stock, such as air hardening steel (which heretofore has had to be notched and broken), brass,

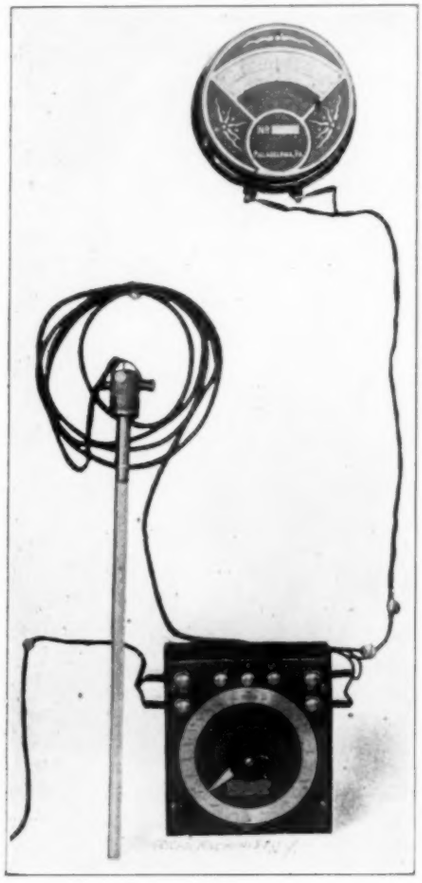


A CUTTING-OFF MACHINE WITH AN ABRASIVE WHEEL

copper or other tubing, flexible tubing either with or without a filling of rubber, webbing or woven wire, etc., and makes a smooth cut without burs. A 5/16-inch square bar of either high-speed or carbon steel can be cut in five seconds and a ½-inch bar in 10 seconds without drawing the temper. Steel, nickel or brass tubing ½ inch in diameter can be cut off in two seconds leaving a true clean end without any bur. The machine weighs 200 pounds, will cut stock up to 2½ inches in diameter and is made by the Slack Manufacturing Company, Springfield, Vt.

A New Type of Pyrometer

The accompanying illustration shows a pyrometer which is the recent product of the Leeds & Northrup Company, of 4901 Stenton avenue, Philadelphia, Penn. The



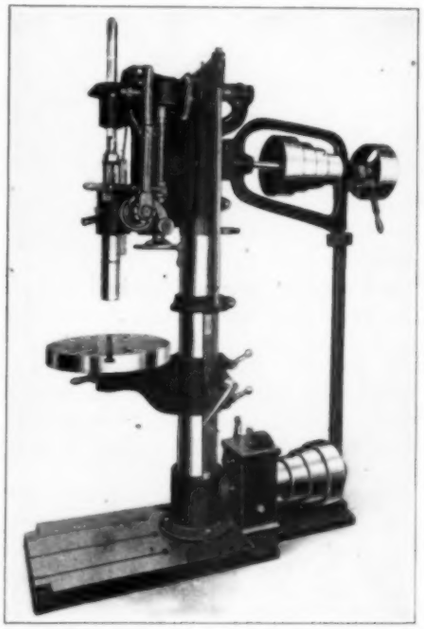
A NEW TYPE OF PYROMETER

instrument depends for its working upon the change in the electrical resistance of pure platinum under variations of temperature. In addition to the bulb which contains the platinum and which is inserted in the furnace, the instrument consists of two parts, an indicator and deflector. Of these the first only gives the actual temperature of the furnace. The deflector shows, not the actual temperature of the furnace, but whether or no it is the desired temperature. To this end it contains an adjustable index which may be adjusted to any temperature desired, the position of the needle above or below this index telling whether the temperature is too high or too low, and how much. The indicator is, of course, used in connection with exact temperature of determinations but the workman at the furnace may or may not see it, as desired.

In addition to the obvious advantage that the deflector tells the workman just what he wants to know, it makes feasible the use of a much more coarsely graduated scale than the customary construction. Whereas with the customary construction the length of this scale must be divided so as to indicate the entire range of the instrument, in the present case it may be graduated to contain only the variation of temperature to be anticipated in the furnace. That is, whereas the usual construction involves the division of the scale to give readings from 0 to 2000 degrees, the new method enables this entire length of scale to be given to a range of no more than 500 or even 200 degrees, the indications being from four to ten times as coarse.

A 22-inch Drilling and Tapping Machine

The column is bolted to the base and is provided with a back-support bracket. The drive is by 2¾-inch belt. Four-step cones of large diameter are used. The back gears can be thrown in or out while the machine is in motion. The feed is geared and has 24 changes. The spindle is 1¾ inches diameter in the quill with a square through the crown gear to equalize the drive. The machine is furnished with wheel, lever and power feed and automatic stop. The knee is raised and lowered by



A DRILLING AND TAPPING MACHINE

crank with worm gear and pinion on the rack. All bevel and miter gears have planed teeth. All clamps are furnished with tail nuts. Hight over all, 77 inches; floor space, 18½x58 inches; table diameter, 18 inches; drills to the center of a 21¾-inch circle; net weight, 1450 pounds. These machines are built by the Robertson Drill and Tool Company, Buffalo, N. Y.

Multiple Spindle Drilling Machine

In this machine the drilling spindles are evenly spaced around a central gear which in turn is driven from the countershaft. An interesting feature is the close spacing with which holes may be drilled, this being less than 0.2 inch from center to center, and accomplished by the use of a special ball-and-pin-joint. The connections between driving and drill spindles are of such a length as to make the angle

MULTIPLE SPINDLE DRILLING MACHINE

very slight, bringing about easy running and reducing the wear on the joints. The lower or drill spindles are held in interchangeable cast-iron blocks bored to give the desired location of holes. These blocks can be reversed so that the holes may be drilled from either side of the work, or in the case of clock plates, the upper and lower members may both be drilled from the inner face. The spindles and joints are of hardened steel and the former have bronze bearings which can

be readily replaced when worn. Holes may be drilled accurately without the use of a jig, by using short drills, and drilled or punched holes may also be reamed and countersunk without a jig, although provision is made for using a jig when required. The work table may be operated either by a hand wheel or lever connected to a pinion and rack and an adjustable stop is provided for regulating the depth of drilling. A screw adjustment is also provided for independently setting each spindle in the required vertical position. Two sizes of the machine are made; the larger is adapted for clock and similar work, weighs 240 pounds, and is made with any number of spindles up to 14, these drilling in any position within a 6-inch circle. The smaller or watch size weighs 50 pounds, is fitted with any number of spindles up to eight, and will drill inside of a 3½-inch circle. In the larger machine, ball bearings are used for end thrust, but these are not necessary in the small size. The drive of the larger drill is through spiral gears so that the machine can be belted direct from the counter, while in the smaller machine the drive is direct from the central gear shaft by a quarter-turn belt from the countershaft. The machines are made by the Waltham Machine Works, Waltham, Mass.

A Reducing Gear

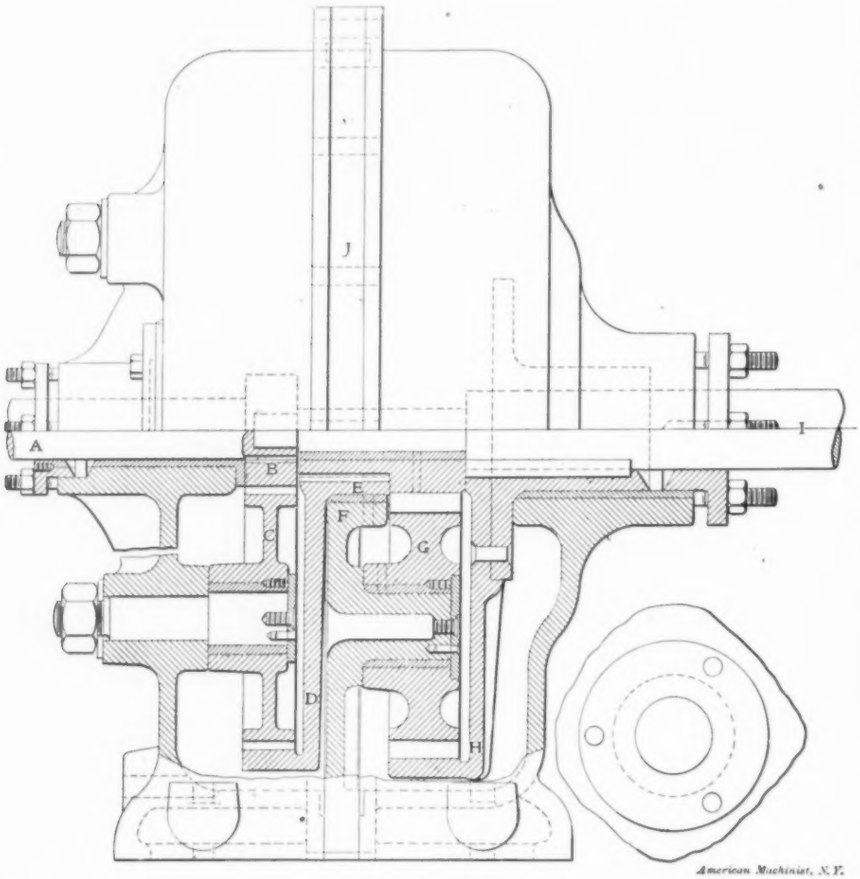
This device is of the spur-gear type and is built with speed reductions from 8 to 1 up to as high as 60 to 1; beyond this the makers advise the use of a worm-geared type of reduction gear made by them.

By referring to the cut it will be seen that the device is neat, compact and motor-like in appearance.

On the end of the high-speed shaft *A* is a pinion *B* which meshes with the idlers *C*, of which there are four equally spaced, but which, of course, do not show in the sectional cut. The idlers *C* engage with the internal gear *D* which has a spur pinion formed on its hub at *E*. From *E* motion is transmitted through *F* to the hub of which the gear *G* is secured. *G* engages with the internal gear *H*, keyed to the low-speed shaft *I*. A central web *J* acts as an inboard support for the slow-speed shaft.

The internal gears rotate in oil, lift it up and flood the working parts with lubricant.

These reducing gears are now built in seven sizes, to transmit from 1 to 50 horsepower, by Foote Brothers Gear and Machine Company, Chicago, Ill.



A REDUCING GEAR

A New High Power Milling Cutter

As with the rivalry between the armor plate and the projectile, so the machine and the cutter are each trying to outdo the other. Having designed a high-power milling machine it was next necessary to get a cutter that would stand up to the work which this made possible. So the Cincinnati Milling Machine Company designed a cutter and with the coöperation of the Union Twist Drill Company are now using and supplying the cutters shown in Figs. 1 and 2.

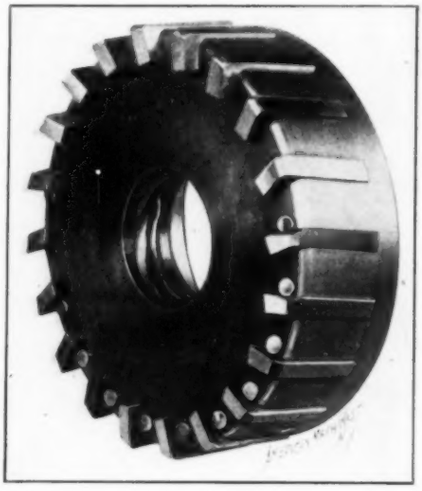


FIG. 1. FRONT VIEW OF CUTTER

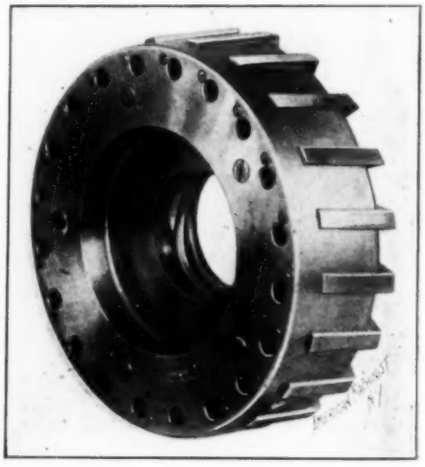


FIG. 2. BACK VIEW OF CUTTER

This has a machine-steel body and backing ring, which is held in place by the large fillister-head screws. The cutters are set with a rake of 15 degrees with the edge of the blank, while the cutting faces have a radial rake of 7 degrees. Each cutter is ½x1¼ inches, is a snug fit in the body and is fastened by the flattened taper pin in front of the cutting edge, the position being adjusted by the small screws at the back. The holes at the back allow the taper pins to be readily loosened.

It will be noted that the thread inside the cutter is quintuple and of a very coarse pitch. This was decided on after several unpleasant experiences with the cutters being forced on so tightly by the working pressure, that it was necessary to remove the spindle to a lathe and cut the cutter body away to get it off. This gives some idea of the power necessary to drive a cutter to do its maximum work.

The angle of the quintuple thread now used has been found to hold the cutter securely, while at the same time it will release easily and yet not work off, with the spindle standing, even if not screwed on tightly.

As an example of what this will do we show, in Fig. 3, a few chips obtained from a 10-inch cutter at work on chrome nickel steel with a tensile strength of 220,000 pounds to the square inch. The cutter had 16 teeth at the start but one broke in the cutter and another burned the corner off, leaving 14 to do the work as the operator did not stop the machine, but

FIG. 3. NICKEL-CHROME STEEL CHIPS FULL SIZE

let the others carry the cut through. This cutter ran 14 revolutions per minute at a feed of 12½ inches per minute and a cut 3/16 inch deep on a piece 3¾ inches wide by 20 inches long. Ten horsepower was required to do the work.

In this connection it is interesting to note that it is strongly advised that the corners of these blades do not have more than ⅛-inch radius as much better results are obtained under these conditions. A larger corner seems to dull more quickly, which means that an enormous end pressure is the result, in some cases being sufficient to force the backing ring off, which means the breaking of all the holding screws. The chips, which are reproduced full size tell the story of what the cutter and machine will do and the cutter failures indicate that the machine is ahead at the present time.

The iron-ore supply of the United States is estimated at 4,785,000,000 long tons, and the production of iron ore of the country in 1907 was 52,000,000 tons.

An Improvised Internal Grinder

By K. A. Juthe

Some time ago it became necessary to enlarge the holes of a number of 18-inch diameter high-speed steel circular saws. None of the shops applied to were in a position to do this job, as the saws were larger than any grinding fixture they had. As the job had to be done, and it was out of the question to do any annealing, the

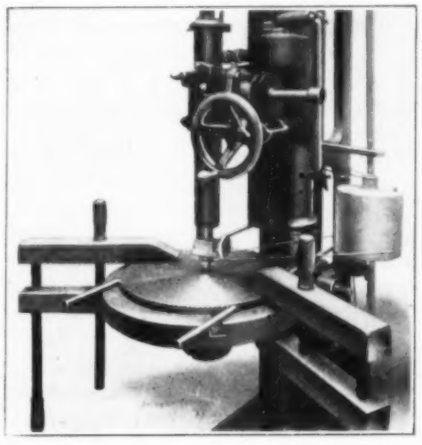


FIG. 1. IMPROVISED INTERNAL GRINDER

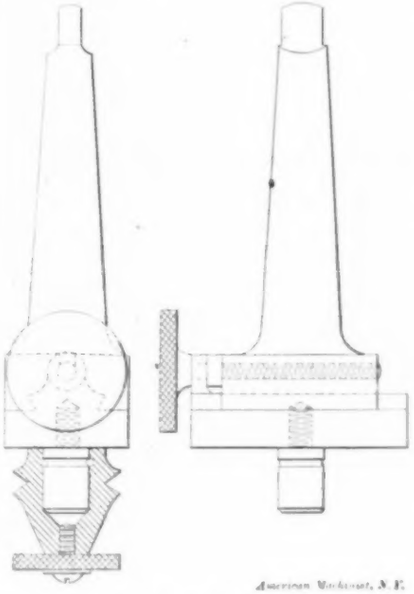


FIG. 2. THE HEAD CARRYING THE GRINDING HEAD

device illustrated herewith was made and used on an ordinary drill press. A drum of wood 8 inches in diameter was turned with a 2-inch diameter driving end. A strap with pointed set screws for centers was clamped on frame of 24-inch drill press, the drum was driven at next fastest speed on cone pulley, by belt running over two small grooved wheels which were also fastened to frame of press. The emery wheel on tool was then belted up with drum, giving an approximate speed of 4000 revolutions per minute which was fast enough to do a good job.

The saws were clamped to drill-press table on drill rod parallels, and centered by plug from spindle. In this way 1/32 inch was ground out of hole in about 15 minutes. The fixture made for carrying the grinding wheel almost explains itself, the cross movement being obtained from the slide on the end. The spindle was run slow enough to allow for adjustment in diameter being easily made and the whole spindle, with wheel, is fed down by hand. There is no argument in this case as to whether a drill press was the best machine for the purpose or not, for the good reason that it was the only machine tool on the premises.

The Supply and Machinery Manufacturers' and Dealers' Associations' Pittsburg Convention

The joint convention of the National Supply and Machinery Dealers' Association and of the American Supply and Machinery Manufacturers' Association held in Pittsburg May 12, 13 and 14, was noteworthy from the emphasis placed upon the quality of manufactured goods and the necessity for maintaining it. The setting of a standard to specifications for first quality goods was maintained to be feasible and it was even urged that the Manufacturers' Association might issue a label to be affixed to goods of the best grade to serve as a distinguishing mark for the consumer—this label to be made use of only through a license. As the outgrowth of this discussion the following resolution was passed:

Resolved: That it is the sense of this, the joint meeting of the National Supply and Machinery Dealers' Association and the American Supply and Machinery Manufacturers' Association, that the standardization of certain lines is not only possible but imperative for the general welfare of not only the manufacturer and dealer, but also the consuming public.

We, therefore, petition the chair to appoint a committee whose membership shall be equally composed of both manufacturers and dealers, whose duties shall be to further investigate this subject.

An entire session of the Dealers' Association was devoted to the subject of machine tools, the chief subject of discussion being an increase of the commissions paid, the dealers advocating an increase to 12½ per cent.

The ever-recurring subject of territorial rights of agents was discussed at length with the result that it was decided that the commission should be paid to the dealer having jurisdiction over the place where the machine sold is finally installed, the settlement of rival claims between dealers

being left to them with the understanding that in cases when one dealer sells in the territory of another he shall have no claim to the commission unless he has made a prior arrangement with the dealer occupying that territory.

The maintaining of prices by manufacturers during the prevailing depression was referred to approvingly by the dealers who, because of goods on hand, would have been large losers had reductions been made.

Resolutions were passed deprecating further agitation against the railroads of the country, except in such cases as "after careful consideration it may be found imperative for the protection of the public interests." The resolutions also pointed out to the railroads that the bringing about of a cessation of hostile legislation lies largely with them through their adoption of "that courteous and considerate attention which every other business organization must extend in order to secure and hold the good will and support of its patrons."

Resolutions in opposition to the establishment of a parcels post and advocating the reduction of a rate of postage on letters to 1 cent were also passed.

Of the Manufacturers' Association, John Trix, of the American Injector Company, Detroit, Mich., was elected president and of the Dealers' Association, W. M. Pattison, of the W. M. Pattison Supply Company, Cleveland, Ohio, was elected to the same office.

Working Exhibition of a Sellers Car Wheel Lathe

On Saturday afternoon, May 15, William Sellers & Co., Philadelphia, Penn., entertained about 75 invited guests at luncheon, and then exhibited one of their new, extra high-power car-wheel lathes in operation. This machine is a recent development following some of the important and demonstrated features of the driving-wheel lathe that was brought out about a year ago.

Four pairs of wheels were turned during the exhibition. It was stated by some of the railway men that the quality of the work produced averaged better than the average of similar work done in railroad shops.

Some Tests of Jessop Ark High-speed Steel—Erratum

By an unfortunate error the tire lathe shown in halftone and referred to in the text of the article under this title published on page 701 was referred to as the product of the Niles-Bement-Pond Company. The makers of the lathe should have been given as Wm. Sellers & Co., Incorporated.

American Foundrymen's Association

The 14th annual convention of the American Foundrymen's Association was held in Cincinnati, O., May 18-20, with the Hotel Sinton as headquarters.

The meeting was well attended and the program unusually attractive. A very thorough report of the committee on the prevention of accidents was presented, and numerous papers dealing with foundry problems and processes were read and well received. The following officers were elected for the ensuing year: President, Arthur T. Waterfall, Russell Wheel and Foundry Company, Detroit, Mich.; vice-president, first district, F. B. Farnsworth, McLagon Foundry Company, New Haven, Conn.; second district, Walter Wood, R. D. Wood & Co., Philadelphia, Penn.; third district, Joseph T. Shear, Pittsburg Valve, Foundry and Construction Company, Pittsburg, Penn.; fourth district, William Gilbert, Buckeye Foundry Company, Cincinnati, O.; fifth district, Eugene W. Smith, Crane Company, Chicago, Ill.; sixth district, J. W. Sheriff, Sheriff's Manufacturing Company, Milwaukee, Wis.; seventh district, Alfred E. Howell, Phillips & Berttorf Manufacturing Company, Nashville, Tenn.; eighth district, A. F. N. Clare, Clare Stove Company, Preston, Ont.; secretary-treasurer, Dr. Richard Moldenke, Watchung, N. J.

Forthcoming Meetings

American Hardware Manufacturers Association, joint convention with Northern Hardware Jobbers Association, Pittsburg, Penn., June 9-11, headquarters, Hotel Schenley. F. D. Mitchell, secretary, 309 Broadway, New York City.

Engineers Society of Pennsylvania, first annual convention, Harrisburg, Penn., June 9-10-11, headquarters, Capitol building; E. R. Dasher, secretary.

Railway Master Mechanics Association, annual convention, June 16-18, Atlantic City, N. J. Jos. W. Taylor, secretary, Old Colony building, Chicago, Ill.

Master Car Builders Association, annual convention, June 21-23, Atlantic City, N. J. Jos. W. Taylor, secretary, Old Colony building, Chicago, Ill.

American Society of Testing Materials, annual meeting, June 29, Atlantic City, N. J. Edgar Marburg, secretary, University of Pennsylvania, Philadelphia, Penn.

Business Items

The Cincinnati Ball Crank Company is moving into larger quarters at Sixth and Jane streets, Cincinnati, Ohio.

The Wagner Electric Manufacturing Company has opened an office in Denver, Colo., located in the Ideal building. This new office is in charge of O. H. Davidson, of the Electric Manufacturers' Sales Company. Mr. Davidson will have charge of the Wagner company's business in Colorado, New Mexico, Utah, Montana and eastern Idaho.

The Youngstown Sheet and Tube Company, Youngstown, Ohio, has added to its 5000 horsepower of Crocker-Wheeler motors by installing a 500-horsepower synchronous motors, aggregating 655 horsepower, of the Ind., has placed an order for 21 Form W motors, aggregating 655 horsepower, of the type developed by the Crocker-Wheeler Company for rolling-mill process.

The Warner & Swasey Co. has just purchased the unoccupied half of the Brown & Sharpe lot on Washington boulevard, Chicago, and will at once erect a building for its Chicago office, with large showrooms for the display of its complete line of machine tools. The lot has a frontage of 75 feet, the same as that of the Brown & Sharpe store which it adjoins, and the Warner & Swasey building will be of the same hight and general dimensions as Brown & Sharpe's.

Business Opportunities

The Rumford Falls (Me.) Power Company is building a new power house.

The Heinze Electric Company, Lowell, Mass., is building an addition to plant.

The Falk Company, Milwaukee, Wis., is building an addition to foundry.

The Universal Boring Machine Company, Hudson, Mass., will enlarge plant.

The Lumen Bearing Company, Buffalo, N. Y., will build a foundry addition to plant.

The plant of the Utica (Ohio) Glass Company was destroyed by fire. It will be rebuilt.

The Grimes Milling Company, Salisbury, N. C., contemplates installing new Corliss engine.

The Findorf Planing Mill, Madison, Wis., was destroyed by fire. Loss, over $100,000.

The Locomobile Company of America, Bridgeport, Conn., is planning to erect an addition.

The Leach & Garver Co., Attleboro, Mass., jewelry manufacturer, will erect a new factory.

The Hupp Motor Car Company, Detroit, Mich., has let contract for the erection of a new plant.

The Canadian Kodak Company, Toronto, Can., will erect a new $50,000 factory and warehouse.

The West Hampton (L. I.) Ice Company is erecting a new building for its new 15-ton ice plant.

The Wright Brothers will establish a factory at Dayton, Ohio, for the manufacture of aeroplanes.

Rogers & Acker, Bridgehampton, N. Y., have opened a garage and will install new machinery.

The plant of the Lake Chelan Box Company, Chelan, Wash., was destroyed by fire. Loss, $25,000.

Fire destroyed the plant of the Beamer Handle Company, Manor, Penn., causing a loss of $100,000.

The Clark & Baker Co., Ilion, N. Y., will erect a new building for cabinet work. Electric power will be used.

E. N. Smith, Peoria, Ill., formerly of Smith & Carpenter, has secured permit for a one-story machine shop.

The General Fire Extinguisher Company, of Providence, R. I., will erect a new plant at Warren, Ohio.

The Sterling (Ill.) Machine Works is to erect a new plant and will start the manufacture of automobiles.

The E. Ingraham Clock Company, Bristol, Conn., is to erect a five-story addition as well as a new boiler house.

The City Manufacturing Company, New Bedford, Mass., is to erect an addition to mill and a new machine shop.

Geo. W. Swift, Jr., Bordentown, N. J., manufacturing machinery, will erect an addition, doubling capacity of plant.

The Ramapo Iron Works Company, Niagara Falls, N. Y., contemplates erecting a branch factory on the Canadian side.

The Graton & Knight Manufacturing Company, Worcester, Mass., making leather belting, will erect a five-story addition.

The International Steam Pump Company, of New York, is said to be preparing list of machinery required for its various plants.

Geo. C. Christopher & Son, Wichita, Kan., will erect a new plant for the manufacture of structural steel, mixers, stone machines, etc.

The Rogers & Hubbard Co., Middletown, Conn., is said to be interested in a gas-producer outfit for a fertilizer plant at Portland, Conn.

Corbitt Buggy and Surrey Manufacturing Company, Henderson, N. C., is planning to establish plant for the manufacture of automobiles.

A. N. Bronstein, Polskay 8, Odessa, Russia, would like to correspond with manufacturers of hardware, engineering tools, hand tools, machine tools.

The Whiting Manufacturing Company, of New York, silverware manufacturers, will locate in Bridgeport, Conn., where new plant will be erected.

The American Mill and Lumber Company, Eugene, Ore., will double capacity of planing mill. New machinery to cost $6000 will be installed.

The Rogers, Pea Ridge and Northern Interurban Railway will erect repair shop and power plant at Rogers, Ark. Bryan Snyder, Rogers, secretary.

The Cosmopolitan Engineering Company, of Pittsburg, Penn., which manufactures ornamental and structural iron, will locate in Uniontown, Penn.

The Toledo (Ohio) Machine and Tool Company, which recently installed some new tools, is now in the market for four additional lathes 24-inches and 28-inches.

The Oxford Paper Company, Rumford Falls, Me., is erecting a new building to be used for the production of bleaching fluid. Electric motors are to be used.

Pittsburgh Plate Glass Company, Frick building, Pittsburgh, Penn., is in the market for B. & W. water-tube boilers from 500 to 1500-horsepower in units of 250-horsepower each.

Bids will be received at the U. S. Engineers' Office, Pittsburg, Penn., up to 12 o'clock noon, June 9, for furnishing and installing a water-power air-compressor plant at Brownsville.

The Struthers (Ohio) Furnace Company is to build a modern blast funace, with skip hoist, pig machine and other equipment, to involve an expenditure of nearly $1,000,000.

The Century Manufacturing Company, of New York, making gas stoves, etc., has bought site in Ogdensburg, N. Y., for a branch plant for the manufacture of motor-boat specialties.

Anders Hellstrom, 30 Sodra Stromsgatan, Norrkoping, Sweden, about to start in business, is inquiring for general machinery, agricultural machinery, pulp, paper and pumping machinery, metal boring machinery.

The Hampton Roads Cutlery Company, Norfolk, Va., a recently organized concern, is preparing to erect a plant. Chas. T. Alexander, vice president of the Norfolk Veneer Company is president of the new concern.

The Pullman Company, Chicago, Ill., which some time ago erected a building in which the manufacture of steel cars was started, will now start the erection of additional buildings, to include two erecting shops, power house, freight car shop, brass foundry and finishing shop. It is said about $3,000,000 will be spent.

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open the following bids: June 1—copper (schedule 1279), ferrosilicon, ferromanganese, pig iron, german silver (schedule 1282); June 8—water heaters (schedule 1293), leather packing, gate valves (schedule 1292), files, air hose, brass wood screws (schedule 1291).

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open the following bids: June 8—Crane, pipe expanding and flanging machine (schedule 1272), bolts, lead smelting furnace, steel bars (schedule 1274), wire (schedule 1244), pipes and fittings (schedule 1274); June 22—Engine lathe, bench grinder, crank shaper, drill press, drill chuck, threading tools (schedule 1262); disk grinder, two-spindle centering machine (schedule 1263); erecting drop-hammer furnace (schedule 1264).

New Incorporations

The Badger Engineering Company, Milwaukee, Wis., has been organized by A. J. Simons, E. B. May, H. M. Miller. Capital, $250,000.

The Apalachicola (Fla.) Manufacturing Company has been organized with $25,000 capital to manufacture boxes and baskets. M. Brash, president.

The International Metal Products Company, Jersey City, N. J., has been incorporated with $100,000 capital. Incorporators, R. P. Caldwell, Frank H. Simpson, Wm. G. Caldwell.

The Vibrator Company, Buffalo, N. Y., has been incorporated to manufacture vibrators and other machines. Capital, $10,000. Incorporators, Chas. A. Smith, Jas. J. Lanahan, F. W. Zander.

The Thomas Manufacturing Company, Chicago, Ill., has been incorporated to manufacture machinery, novelties, etc. Capital, $10,000. Incorporators, Chas. A. Stevenson, L. S. Le Bocky, S. T. Johnson.

The Krauss Engineering Company, New York, has been incorporated to manufacture ice machinery, heating apparatus, etc. Capital, $25,000. Incorporators, E. Krauss, R. G. McKinnon, J. J. Hegt.

The Daisy Safety Razor Company, Jersey City, N. J., has been incorporated. Capital, $50,000. Incorporators, Wm. H. Rees, Chas. C. Kelly, George W. Rurode. Will manufacture safety razors and appliances.

The Waterman-Waterbury Company, of Buffalo, N. Y., has been incorporated to manufacture heating and ventilating devices. Capital, $300,000. Incorporators, P. L. Pease, J. T. Gething, F. K. Waterman.

Want Advertisements

Rate 25 cents per line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E. G. Smith, Columbia, Penn.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Hand power bending tools labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Accurate tool and instrument work; small manufacturing. W. H. Nichols, Waltham, Mass.

Light, fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

A large foundry and machine shop desires to add to present lines of manufacture. Box 136, AMERICAN MACHINIST.

Special machinery accurately built. Screw machine or turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

Machines designed; automatic, special. Practical working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia, Pa.

Light and medium weight machinery and duplicate parts built to order; tools, jigs, etc. MacCordy Mfg. Co., Amsterdam, N. Y.

Wanted—Firm to manufacture duplicate parts or the completed articles of a line of small drop-forged tools on contract and in quantities as desired. Box 260, AM. MACH.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMERICAN MACHINIST.

Wanted—From 500 to 1500 horsepower of B. & W. water tube boilers in units of 250 horsepower each. Must be in A-1 condition. Inquire of J. F. Cargill, Room 1630, Frick Building, Pittsburgh, Pa.

One of the largest high-grade steel works, whose manufacturing line comprises fine tool steel of all grades, in bars and sheets, answering all demands and purposes, including high speed steel, construction material, nickel steel and chrome nickel steel for automobiles, magnet steel and finished magnets, has decided to engage in the exportation of its product to the United States. It intends to either establish a branch office of its own in New York, or to grant the sole right of sale in the United States to a firm of the highest financial standing and with an established and splendidly organized selling department at its command. The German works has even at the present time excellent financial connections with the United States, and likewise maintains close business relations with several of the largest manufacturing concerns. Such firms as would be willing to take charge of the exclusive sale, or persons qualified to manage a branch office, are requested to kindly mail their applications, marked "K. 06796," to Rudolf Mosse, Cologne, Germany.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Position as foreman or superintendent wanted; thoroughly up-to-date; accustomed to accurate and intricate work; 15 years with one of the largest manufacturing establishments in the East; satisfactory reasons for changing; New York or vicinity preferred. Box 233, AM. MACH.

DELAWARE

Tool and diemaker wants position; will go anywhere. Address Box 226, AMER. MACH.

Mechanical draftsman, experience mostly on machine tools, wishes to change. Box 225, AMERICAN MACHINIST.

GEORGIA

Wanted—Position as factory engineer or chief electrician in large industrial establishment. Cornell graduate with extensive experience in this line of work. Propositions wanted only from large concerns, requiring man of ability and experience. Box 239, care AM. MA.

Cornell graduate, age 32, desires change of position. Practical experience includes power plant and shop superintendence; electric and pneumatic power distribution; applications of electricity in manufacturing plants, particularly individual motor drive; specification work and correspondence. Broad knowledge of general machinery. Executive and business ability. Highest endorsements. Box 240, AM. MACH.

ILLINOIS

An expert designer with experience on presses and sheet-metal machinery, special machinery and machine tools, wants work. Box 258, AMERICAN MACHINIST.

INDIANA

Mechanical draftsman with wide experience on jigs, tools, fixtures, gages, special and automatic machines. Capable of taking charge of tool room if necessary. Desire to go West. Box 251, AMERICAN MACHINIST.

NEW JERSEY

Automatic operator; expert on Cleveland and Brown & Sharpe; capable of designing cams and taking charge; fifteen years' experience. Box 255, AMERICAN MACHINIST.

Automatic scale expert desires change. One who knows what the automatic scale is up against in giving satisfaction and who can remedy it. Box 222, AMERICAN MACHINIST.

Mechanical draftsman and machinist wants position. Expert on the oxy-acetylene metal welding and cutting process. Will install my own process if desired. Box 236, AM. MACH.

NEW YORK

Superintendent of large successful concern desires change. Box 235, AMER. MACHINIST.

Mechanical draftsman wishes position; four years' experience, also shop experience. Box 254, AMERICAN MACHINIST.

Machine shop foreman, a first-class machinist, toolmaker and all around man in all branches. Box 237, AMERICAN MACHINIST.

Progressive machine shop and factory superintendent; very successful organizer and cost reducer; wants to change. Location immaterial. Box 246, AMERICAN MACHINIST.

Technical man, A-1 mechanic with 11 years' drafting room experience, wishes position. Four years as executive in two departments. Box 252, AMERICAN MACHINIST.

Engineer, 30 years old, technical graduate, desires position as works manager or superintendent; four years' shop and drafting; four years installing cost and shop systems. Box 257, AMERICAN MACHINIST.

Mechanical engineer, 32, 12 years' shop and engineering experience, thoroughly up-to-date, wants to correspond with progressive firm on the Pacific coast. Excellent training on exact work and economical production; good executive; energetic and silent worker. Box 256, AMERICAN MACHINIST.

OHIO

First-class planer hand wants responsible position. Capable of handling gang of men with good results. Box 217, AMERICAN MACH.

Superintendent of factory doing sheet-metal stamping or building light and medium machinery; long, practical experience handling this kind of work; energetic, reliable and hustler; now employed in similar capacity; prefer place where the right man could take financial interest. Box 259, AMER. MACH.

PENNSYLVANIA

College graduate, 13 years' experience; chief draftsman, estimator and practical systematizer, desires change. Box 250, AMERICAN MACH.

Mechanical engineer, 31 years of age, of established reputation, technical education, 12 years' experience as designer, chief draftsman and superintendent. Expert on special machinery. Experienced and qualified to direct work and handle men. Understands factory and construction gang organization, shop production and economy. Is open for position as mechanical engineer or superintendent of construction; best of references. Box 232, AM. MA.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CANADA

Mechanical engineer wanted for charge of designing and drafting office for large engineering works. Give experience. Address Box 249, AMERICAN MACHINIST.

Mechanical engineer wanted to take charge of outside construction. Give experience. Box 248, AMERICAN MACHINIST.

CONNECTICUT

Wanted—Six first-class die makers on buckle work. Permanent positions for good men. Apply to Robert N. Bassett Co., Derby, Conn.

ILLINOIS

Wanted—General foreman or assistant superintendent by an old established concern making high-grade stationary gasolene engines. Must be experienced on this class of work, but also must be man who thoroughly understands rapid production, who is young and full of energy and a thorough executive. Only a man who thoroughly understands his business is desired. Location in city of 30,000 people. Concern is now producing 25 engines per day. State fully experience, whether married or single; also salary expected. Box 218, AM. MA.

MARYLAND

Wanted—Three or four first-class draftsmen on heavy machinery and marine engines. Box 247, AMERICAN MACHINIST

MASSACHUSETTS

Wanted—Man capable of taking charge of steam plant and mill repairs in large paper mill in New England. Seven days a week. State age, experience and salary expected. Only men now employed need apply. Apply to Box 238, AMERICAN MACHINIST.

We are looking for a general foreman of machine shop to act as assistant superintendent in factory building the highest possible grade of special machine tools. This is a fine opening for an honest, conscientious mechanic who has had good training in progressive up-to-date shops. Box 244, AMERICAN MACHINIST.

Wanted—Foreman for drop forge department in large manufacturing plant. Must be up and coming and produce results. Prefer man who has also had experience in the making of dies and knows what to do to rectify errors in trying out of the same. Splendid opportunity for the right man. Address, giving qualifications, "B. F. T.," AMERICAN MACHINIST.

MICHIGAN

First-class cost man for automobile axle factory. Wanted only good man of experience in this line of work. Good chance for advance in position and salary. Box 199, AMER. MACH.

Wanted—A man capable of handling a screw-machine department of about 40 machines consisting of National-Acme automatics, Jones & Lamson and hand screw machines, to act as assistant foreman. We want a man who has had good practical training on a good class of work. Will pay good wages. Box 230, AMERICAN MACHINIST.

NEW JERSEY

Wanted—Representatives in different localities to handle the well known line of Reeves compound and simple steam engines, and Reeves-Graef marine and stationary gas, gasolene and producer gas engines. In answering write fully. Trenton Engine Company, Trenton, N. J.

NEW YORK

Wanted by July 1, first-class lathe hands, screw-machine hands, milling-machine hands, toolmakers and motor assemblers. Maxwell-Briscoe Motor Co., Tarrytown, N. Y.

Wanted—A few draftsmen familiar with switchboards and station lay-outs. Apply "Engineer in Charge," Drafting Department, General Electric Company, Schenectady, N. Y.

Wanted—Draftsmen capable of designing gauges and tools for small interchangeable parts. State age, experience and salary expected. Address "Instruments," AMER. MACH.

Wanted—Foreman for a large sheet-metal department. Practical man with experience in designing of large dies for blanking and forming automobile bodies, sheet-metal furniture and other large stampings; must be a man of executive ability and capable of taking full charge of department. Address, "Sheet Metal," AMER. MACH.

OHIO

Wanted—Draftsman experienced on Corliss and pumping engines. State age, experience and salary expected. Good opportunity to advance. Location, Ohio town of 6000. Address "Engineers," care AMERICAN MACHINIST.

Assistant foreman for a machine shop manufacturing transmission, conveying and general machinery. Man experienced in modern methods, including thorough training in feeds and speeds. Only live capable man need apply. Give full details of experience, wages and positions previously held, naming employers in first letter. All information held strictly confidential. Immediate opening. Box 242, AM. M.

Head Draftsman—Man experienced in general machinery. To work on board and handle six men under general instructions of chief engineer. Experience absolutely essential on jig work and general design. Further, experience in transmission, conveying, gears, etc., preferred. Good opportunity for live, capable man. Give full details of experience, salary expected and positions previously held, naming employers in first letter. All information held strictly confidential. Immediate opening. Box 241, AMERICAN MACHINIST.

PENNSYLVANIA

Wanted—Experienced cost clerk for automobile factory. Give references and state salary expected. Box 234, AMERICAN MACH.

Wanted—Several first-class tool and die makers on new tools, jigs, dies and fixtures. Please state experience and wages expected. The Adder Machine Co., Wilkes-Barre, Pa.

For Sale

For Sale or Rent—Two-story factory building, 20x80 feet. A. J. Brunson, 149 Crescent Ave., Plainfield, N. J.

For Sale—An up-to-date small repair shop for repairing iron and steel. Shop now running three men. Can be bought for $2000. Box 245, AMERICAN MACHINIST.

Purchaser for No. 2 Farwel milling machine, Grant hobbing machine and Gisholt tool grinder; all practically new and in A-1 condition. Box 243, AMERICAN MACHINIST.

For Sale—United States and Canada can-opener patents. Device holds the can. Works perfect, very easy, opens 15 cans a minute. Royalty considered. G. K. Winchenbach, Waldoboro, Me.

Elliot addressing machine, 22,000 stencil addresses, all machine tool users over the country, list up-to-date, drawers, cabinets and full equipment. Good as new; sell at a bargain. F. W. Cook, 213 W. Spring St., Lima, Ohio.

For Sale—One new Sarco patent boiler feed water meter, type E-7; capacity 66 gallon per minute; 3-inch pipe connections: good fo temperature 350 degrees, pressure 200 pounds The Union Metallic Cartridge Co., Bridgeport, Conn.

For Sale—Well established foundry and machine business in thriving town of six thousand; fully equipped; plenty of work. Splendid opportunity for man with small capital to secure established business. Address C. H. Ruggles, Hope, Ark.

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